176

AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

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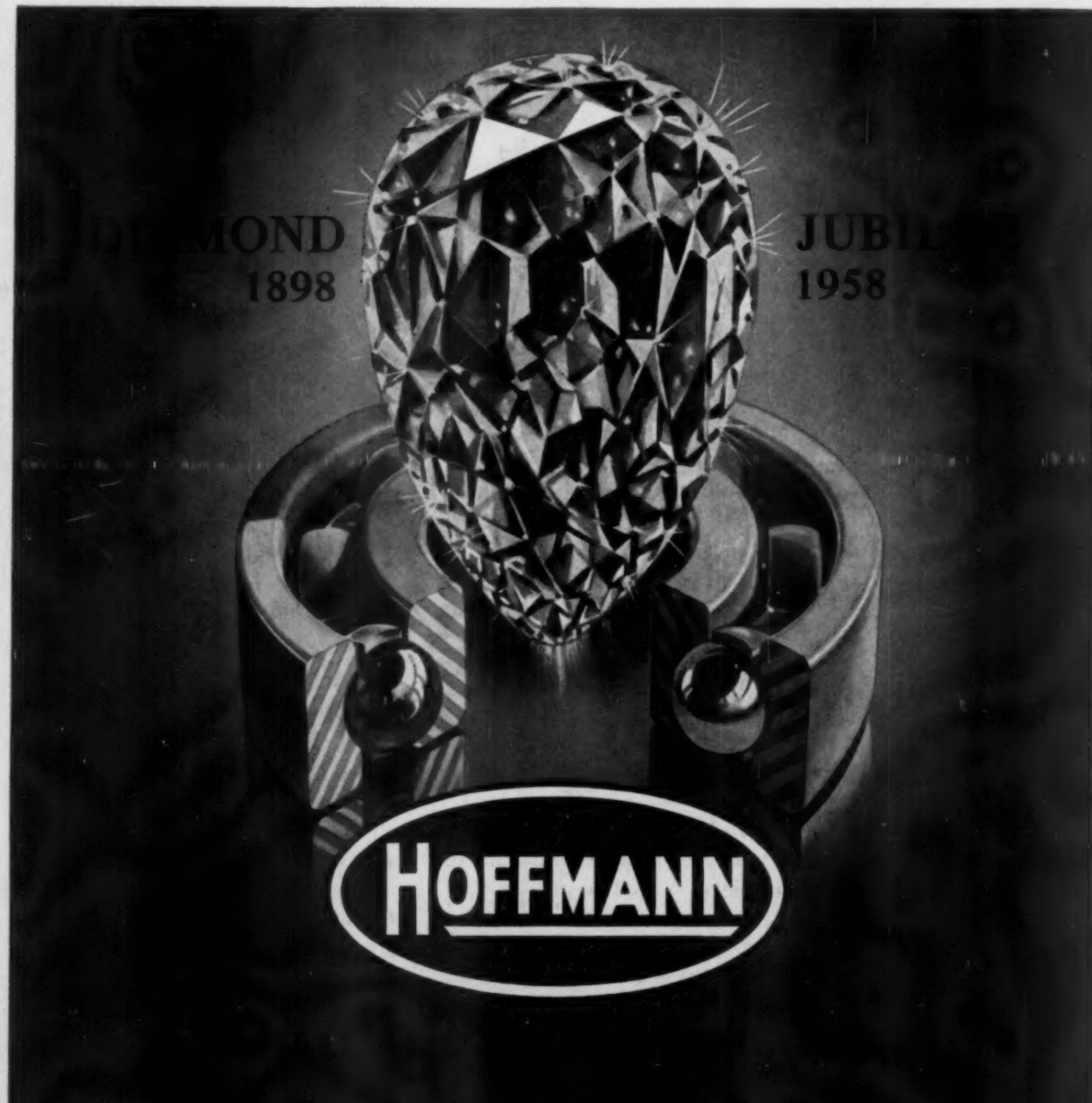


SHELL MEETS THE DEMAND FOR DERV ALL OVER BRITAIN

Whatever route your drivers travel, they can refuel with Shell Derv at the nation-wide network of Shell Derv agencies. At these agencies your drivers can, by showing a Shell Authority Card, refuel on a pre-arranged credit system, or they can pay cash. Ask your local office of Shell-Mex and BP Ltd. for full details of this scheme.

PETROL AGENCY DERV

SHELL DERV

YOU CAN BE SURE OF SHELL

Lockheed commercial vehicle disc brakes are available in two types, single and twin cylinder, each available with a variety of cylinder bore sizes, thus giving complete flexibility of front-to-rear braking ratio to suit the requirements of the vehicle. These disc brakes embody important features as follows :—

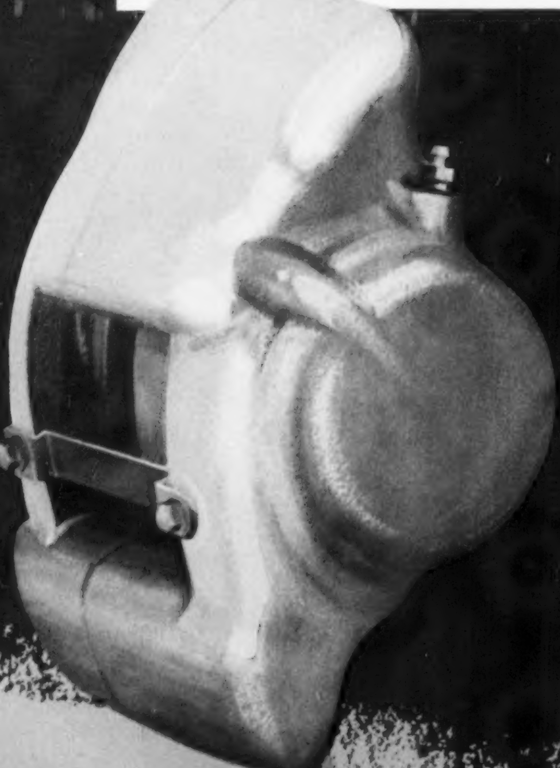
Automatic adjustment of the positive clearance type, giving constant pedal travel throughout the life of the friction pads. The adjusters eliminate rubbing contact, avoiding loss of overall efficiency of the vehicle.

The aperture in the caliper, while maintaining maximum caliper stiffness, permits operator to inspect lining condition at a glance and to remove pads in seconds.

Internal fluid passages give compact design and eliminate external pipes.

LOCKHEED

REGD. TRADE MARK: LOCKHEED



DISC

These new heavy-duty cam-type brakes have been developed specifically for vehicles of 14 tons gross and upwards, and for actuation by hydraulic, air or other means. They incorporate the following features :

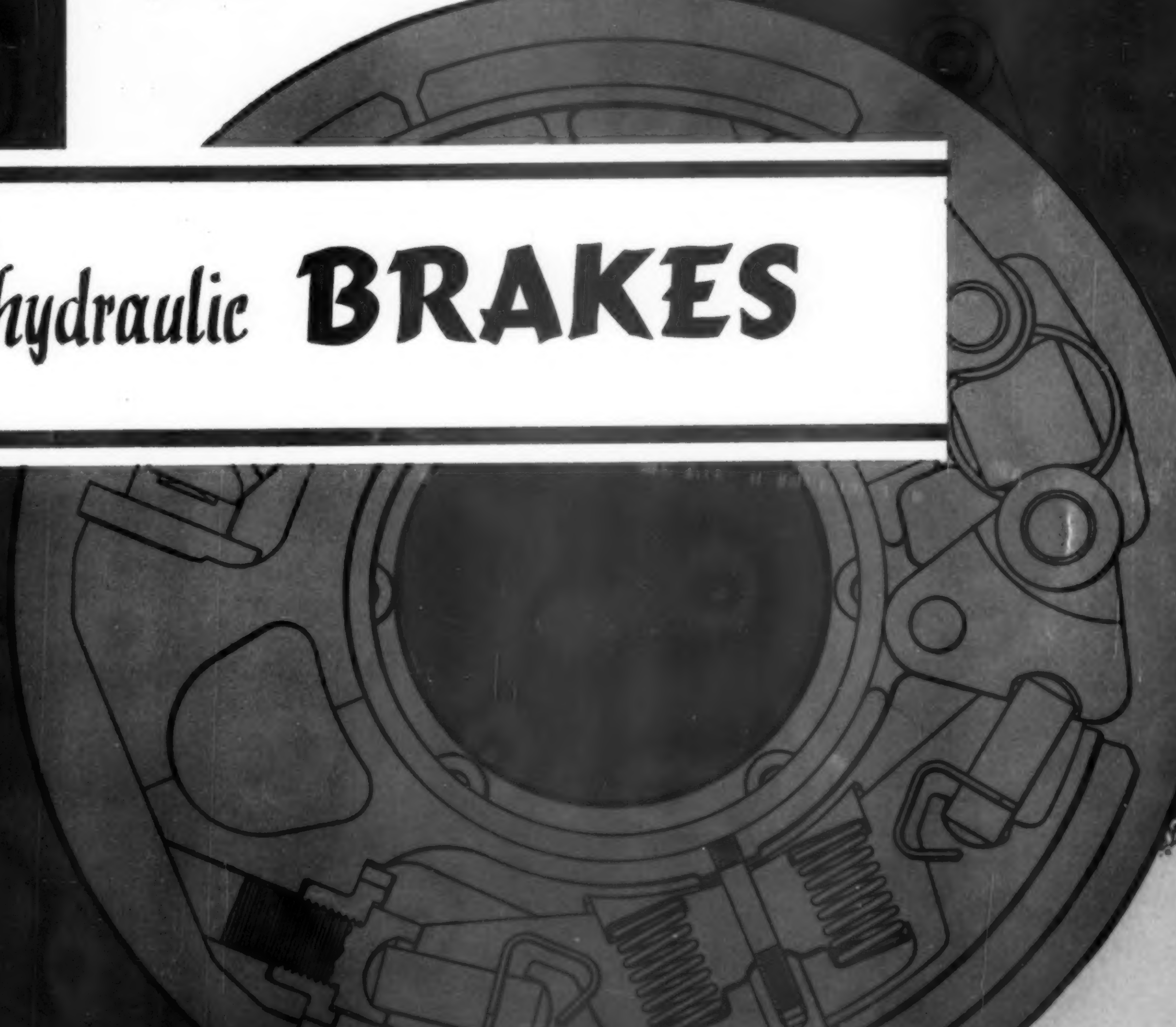
- Fully floating leading and trailing shoes.
- Individual external adjustment for each shoe, thus ensuring that both shoes are correctly adjusted in relation to the drum.
- Shoes mounted on spherically-ended struts, thus minimizing losses.
- Cam-shaft mounted in needle-roller bearings and cam-head designed to give constant rate of lift for the entire lining life.
- Cam-rollers mounted on P.T.F.E. bearings, thus giving very high efficiency.
- Brake incorporates a novel means of retaining the brake shoes without necessitating the normally very difficult operation of removing pull-off springs.

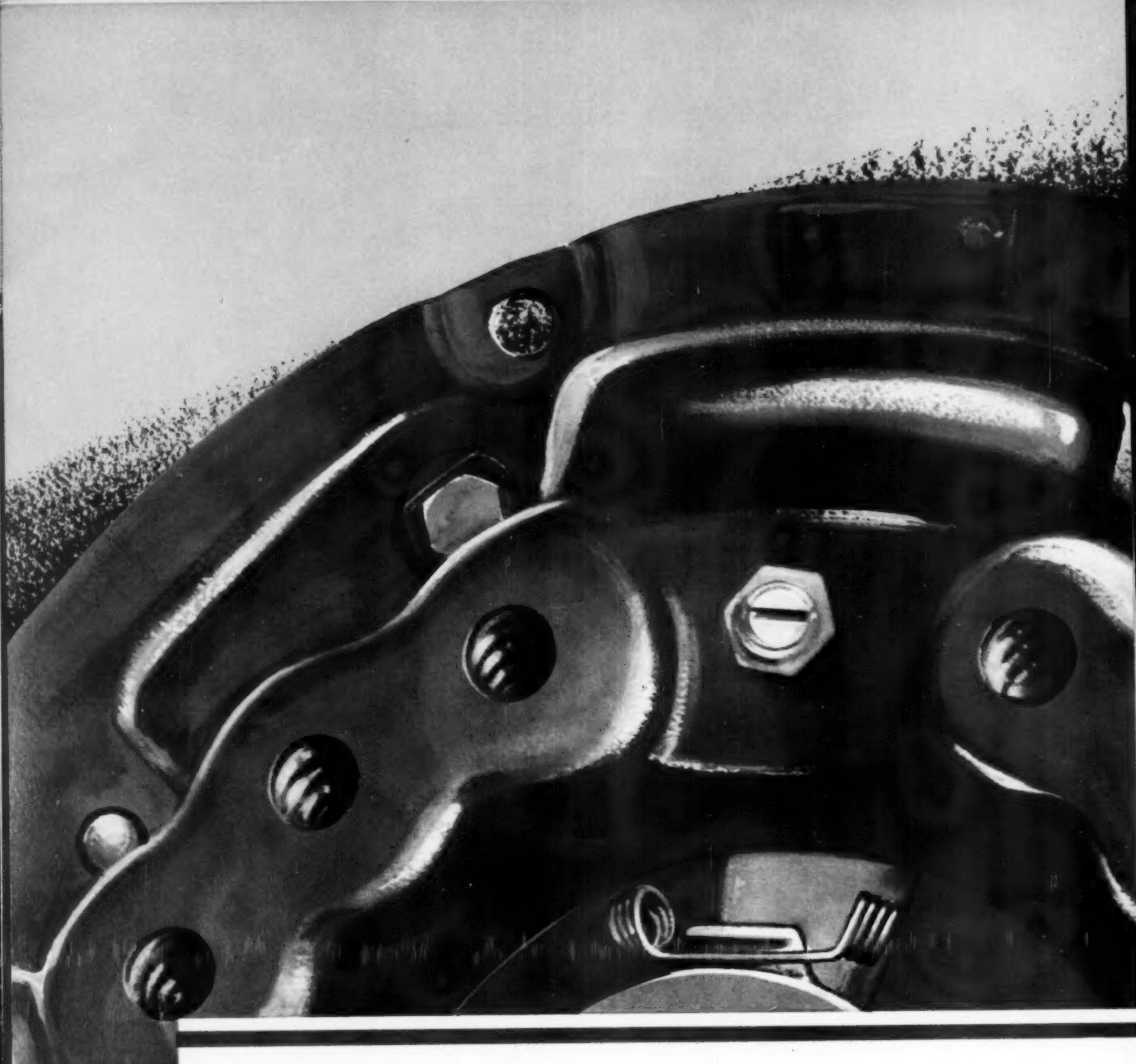
Brake is designed to allow brake drums up to $\frac{1}{8}''$ diameter oversize to be used.

In addition, there is the well-known range of Lockheed hydraulic brakes.

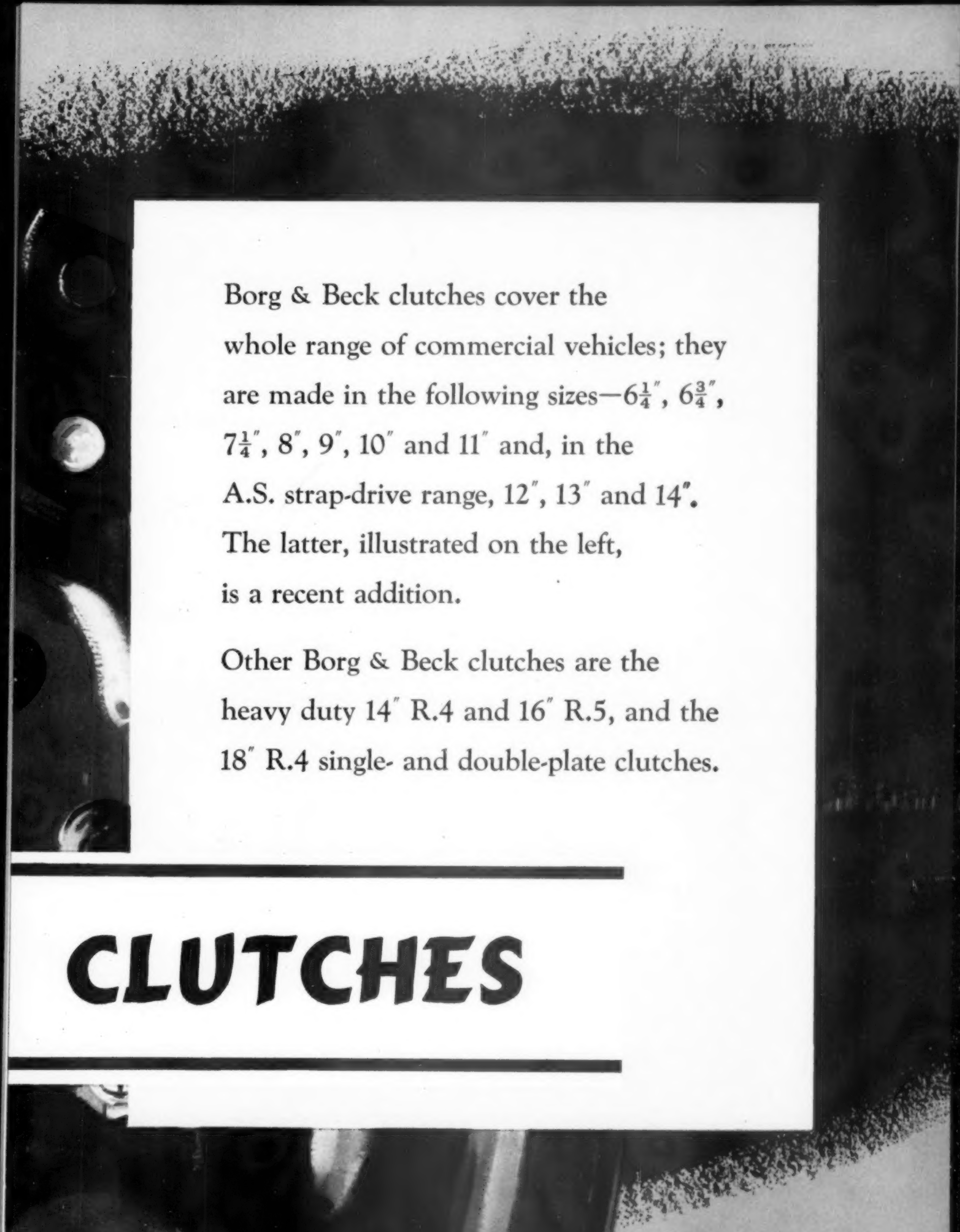
DRUM

hydraulic BRAKES





BORG & BECK
REGD. TRADE MARK: BORG & BECK

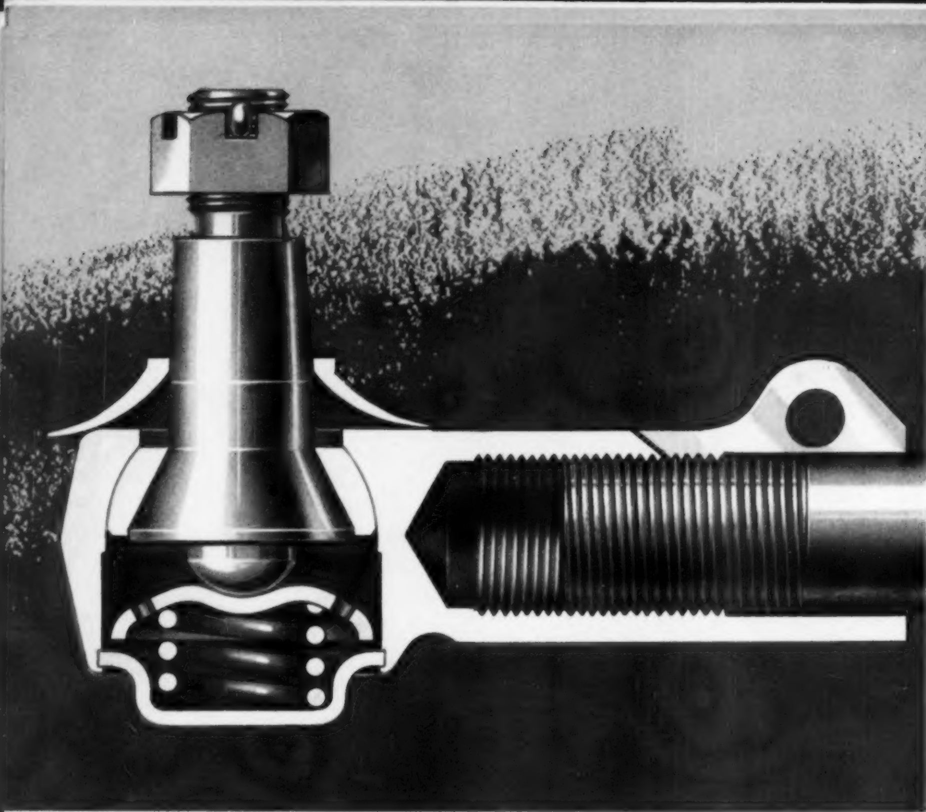


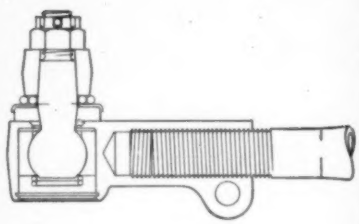
Borg & Beck clutches cover the whole range of commercial vehicles; they are made in the following sizes—$6\frac{1}{4}''$, $6\frac{3}{4}''$, $7\frac{1}{4}''$, 8″, 9″, 10″ and 11″ and, in the A.S. strap-drive range, 12″, 13″ and 14″. The latter, illustrated on the left, is a recent addition.

Other Borg & Beck clutches are the heavy duty 14″ R.4 and 16″ R.5, and the 18″ R.4 single- and double-plate clutches.

CLUTCHES

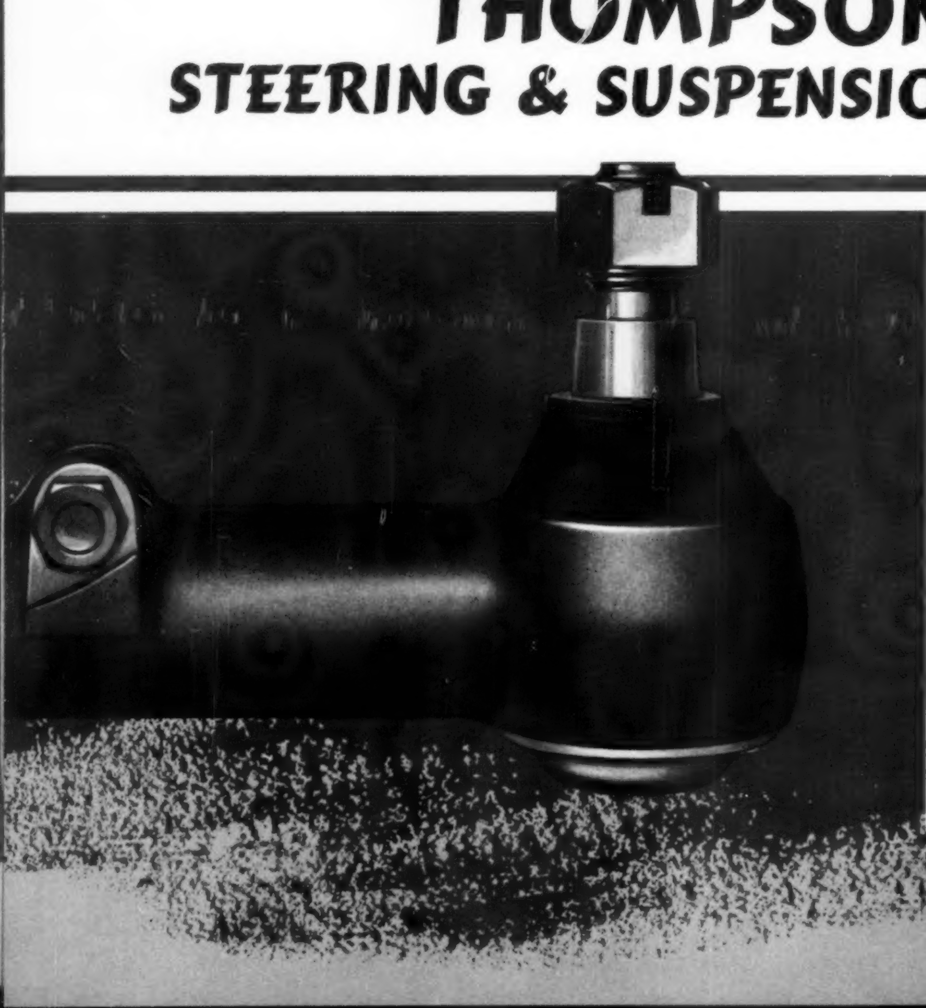

Purolator, first in the field with plastic-impregnated paper filters for fuel and oil, now lead the way with positive air filtration.
'Micronic' air filters are available in a wide range of sizes for throughputs of up to 500 c.f.m.
FILTERS

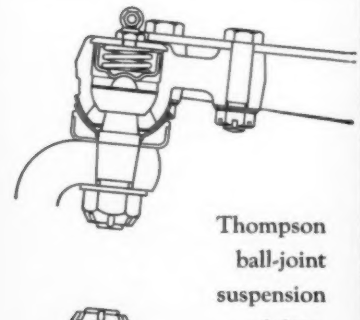




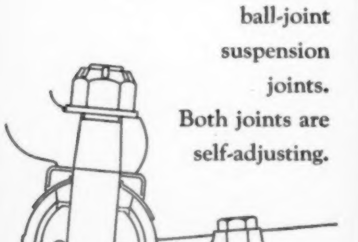
The large illustrations show the dual truck type of Thompson steering joint, now in extensive use. The line drawing above shows the famous eccentric type self-adjusting steering joint, available in several types and sizes for axle weights from 4,000 lb. to 8,500 lb.

THOMPSON
STEERING & SUSPENSION UNITS





Thompson ball-joint suspension joints. Both joints are self-adjusting.

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No. 758. Fine Expansion Springs. 1 gross Assorted $\frac{1}{8}$" to $\frac{3}{8}$", $\frac{1}{2}$" to 2" long, 27 to 20 S.W.G. 15/- each.
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HT 23

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R&M help to put Britain's cars ahead

I've been working on car-engine design for 25 years, and Ransome & Marles bearings have always been specified. I suppose you've contributed to the motor industry for much longer than that?

The motor industry was, in fact, one of the earliest users of R&M products. For just half a century, bearings have been produced at Newark for nearly every British make of car, as well as for commercial vehicles, motor-cycles, auto-cycles, trailers and so on.

And for car accessories?

Certainly. Even brakes and lighting equipment are manufactured on machines which rely on our bearings. And now we are rapidly extending our contribution to the motor industry. It has been estimated that the turbo-driven car will be an economic possibility within two years: with our long experience in designing and manufacturing bearings for gas turbines, we expect to play a prominent part in turning this possibility into a reality. Our research people are fully conversant with all aspects of producing bearings for turbines, and are working continually in this field. Research is also going on into the uses of new materials such as plastics and sintered metals. Our aim is to match the automobile designer's objectives with the most advanced standards of design and production in our bearings.

What about the work Ransome & Marles are doing on bearings for the engines in today's cars?

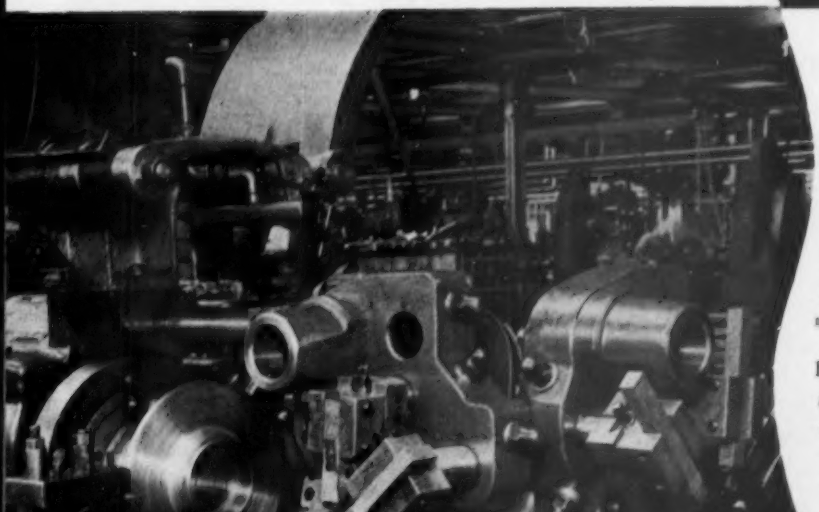
That's still going on, naturally. With the advent of very high compression engines we have been tackling many new problems—and solving them, too. And the introduction of automatic transmission systems in this country has involved us, in production as well as in research. In fact, you can say that R&M have a hand in every technical development of Britain's motor industry, and will continue to have in the future.

Ransome & Marles Bearing Co. Ltd., Newark-on-Trent, England

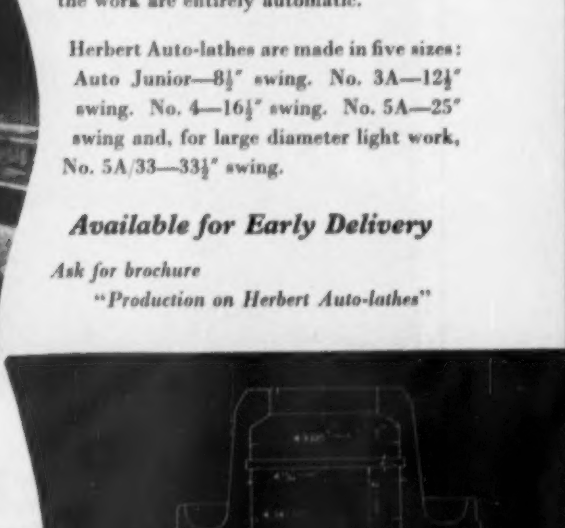
Telephone: Newark 456; and Telex 37-306

BALL & ROLLER R&M BEARINGS

Battery of Herbert Auto-juniors at Moss Gear Co. Ltd.



Herbert No. 4 Auto-lathe at Moss Gear Co. Ltd., machining rear wheel hubs from medium carbon steel forgings.



Cri-Dan *type B High-speed Threading Machine*

will cut any type of thread—

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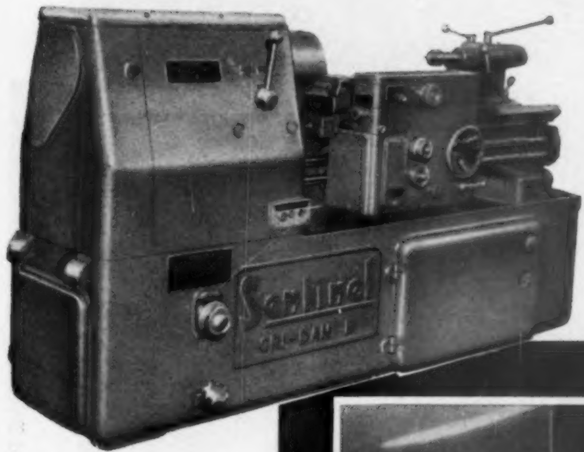
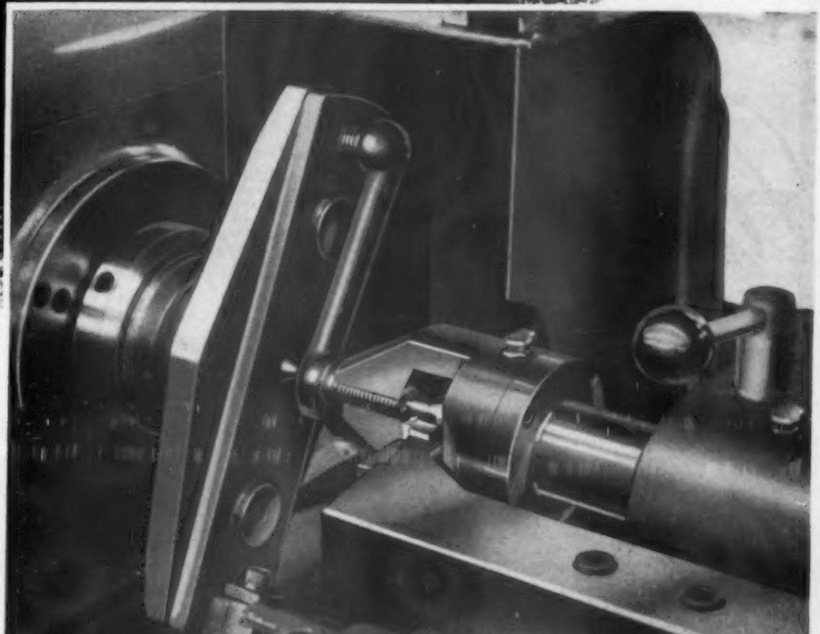
—in any material that can be threaded.



Threads can be cut in a fraction of the time taken on a thread miller or centre lathe and at less expense with greater accuracy and superior surface finish.

Over 500 machines have been installed in customers' works since 1948. This machine combines an old-established principle of cutting a thread with modern tool development and this enables threads to be generated at very high rates of production using semi-automatic cycle and unskilled labour.
Cut threads up to 5 t.p.i. in mild steel on 4" external and 6" internal diameters.



The illustration above shows a typical example of special tooling equipment designed and made to suit customer's components. This particular set-up is for cutting a 11/16" dia. 11 t.p.i. × 1.390" long thread in both ends of a steering idler at a rate of 48 per hour.

ALFRED HERBERT LTD., COVENTRY Factored Division, Red Lane Works.

AH

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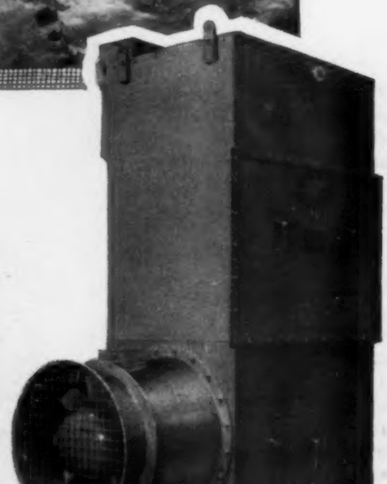

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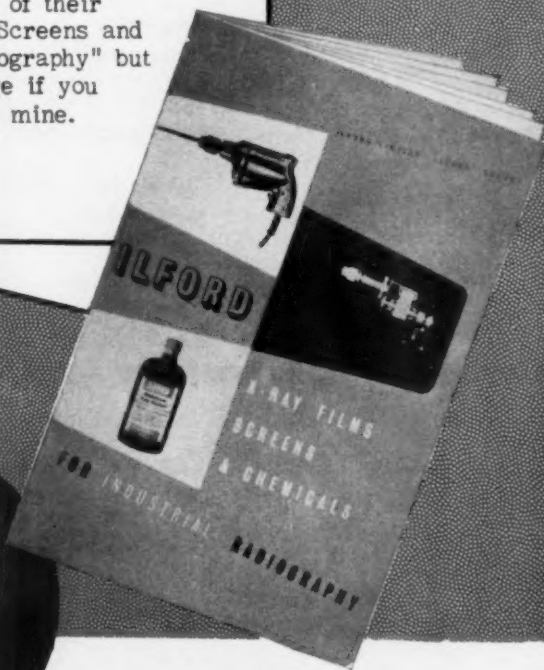
(2)

and if we could land the contract for radiographing these new light-alloy castings, it would be a fine bread-and -butter job for the new X-ray unit.

We must put up a good show, so I suggest you take along some of those Al/Mg undercarriage component rejects which you took on Ilford Industrial X-ray film C. The flaw discrimination is really quite extraordinary.

By the way, you should see what the Ilford people have to say about their Industrial X-ray film G for gamma-ray work. I'm attaching my copy of their booklet "Ilford X-ray Films, Screens and Chemicals for Industrial Radiography" but they'll send one free of charge if you write. Don't forget to return mine.



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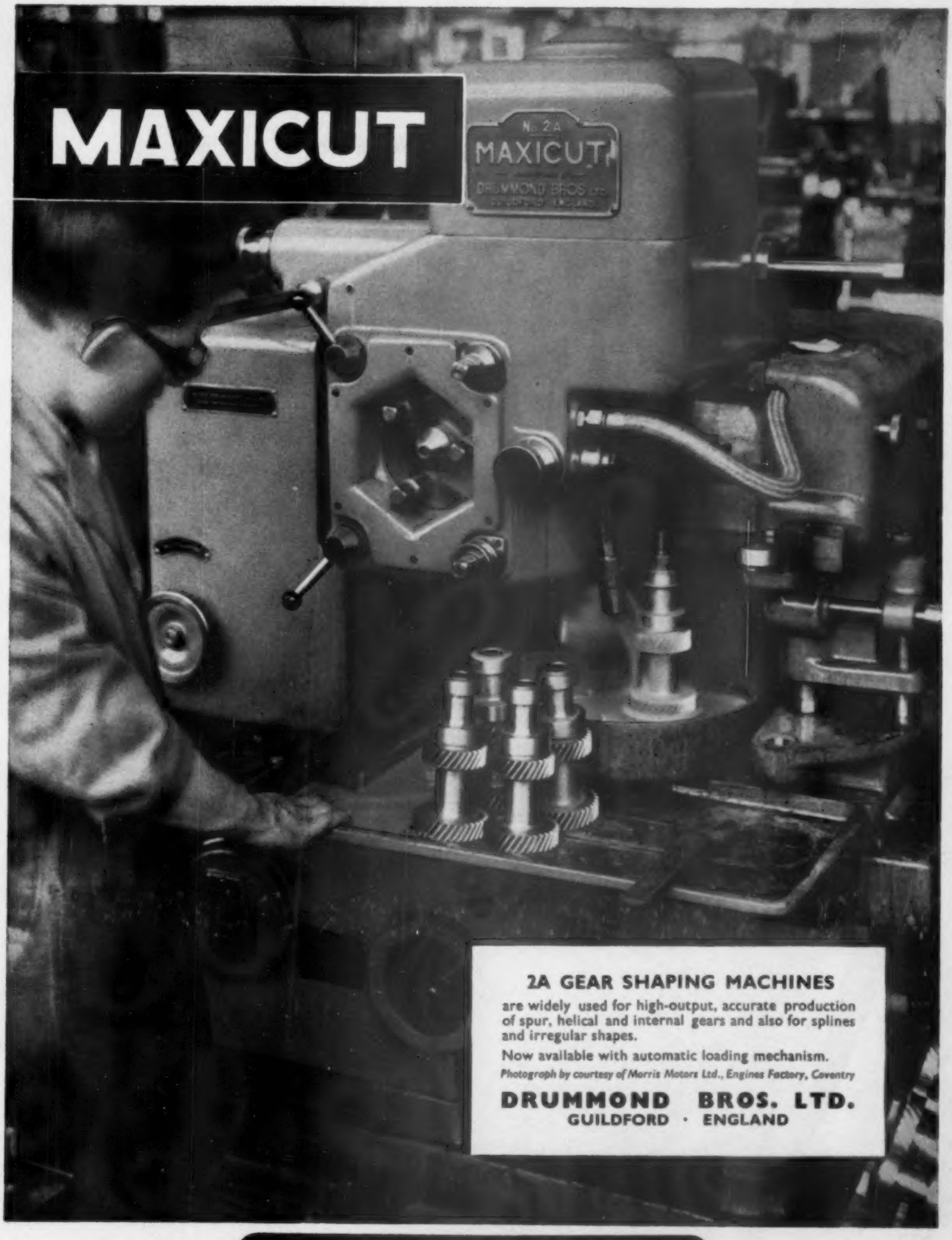
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Photograph by courtesy of Morris Motors Ltd., Engines Factory, Coventry
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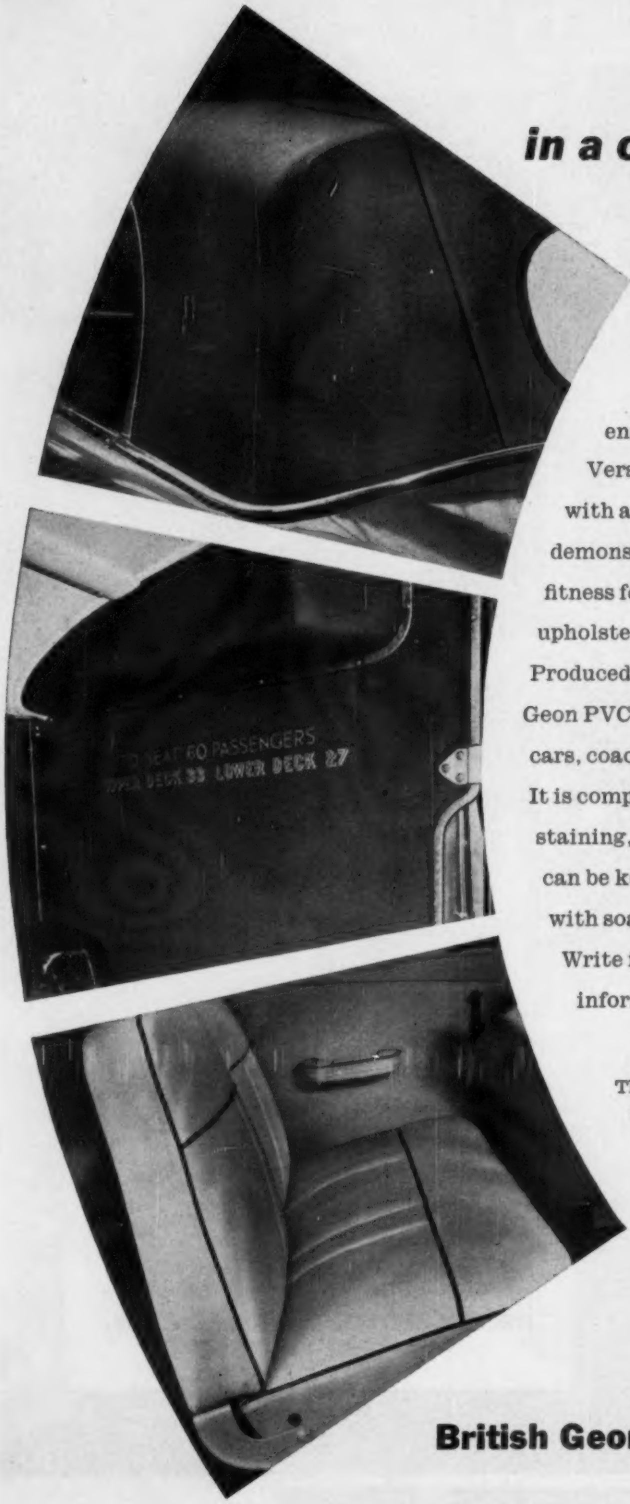

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The illustrations show three uses of Everflex leathercloth made by Bernard Wardle (Everflex Ltd) with Geon PVC.

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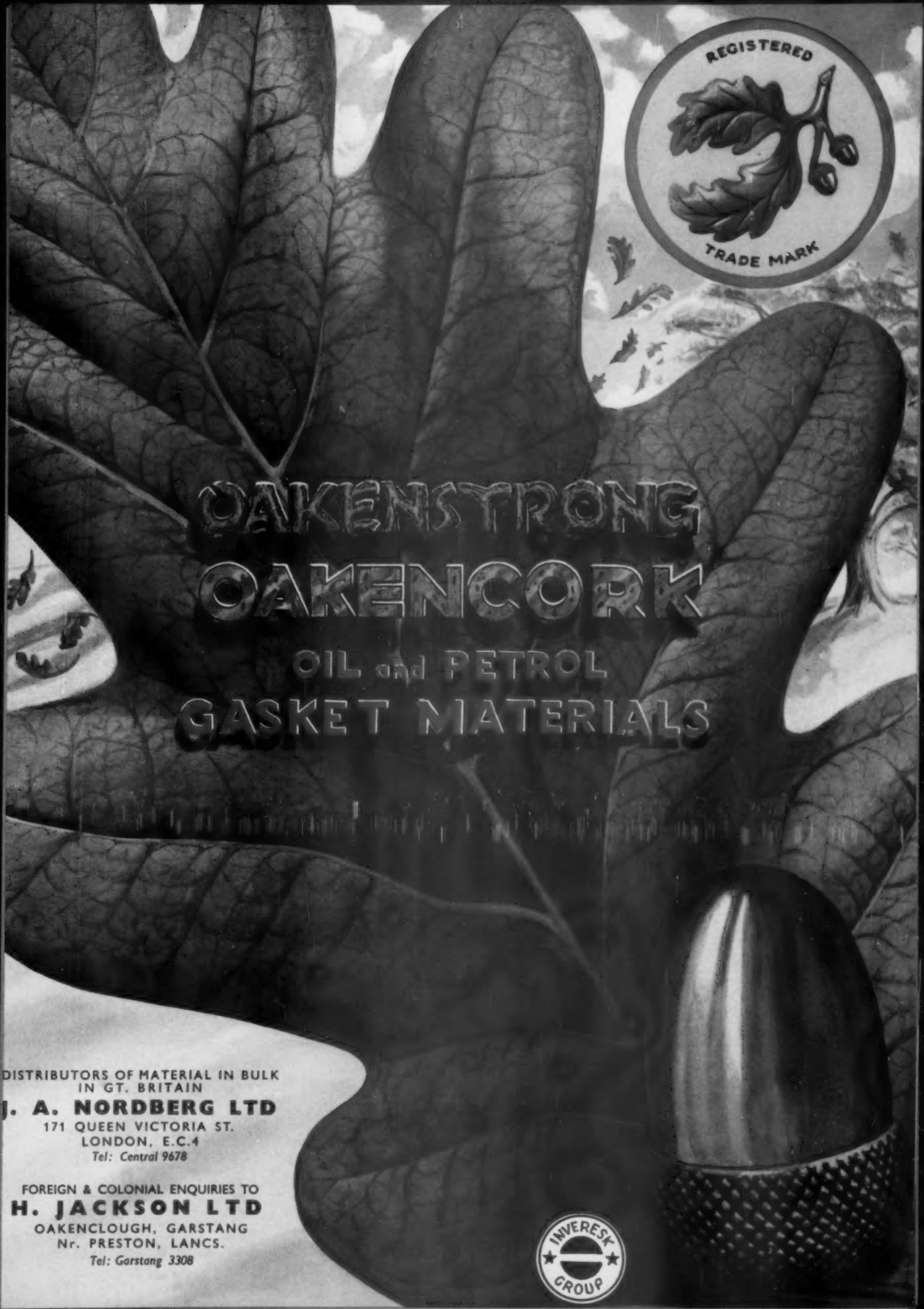
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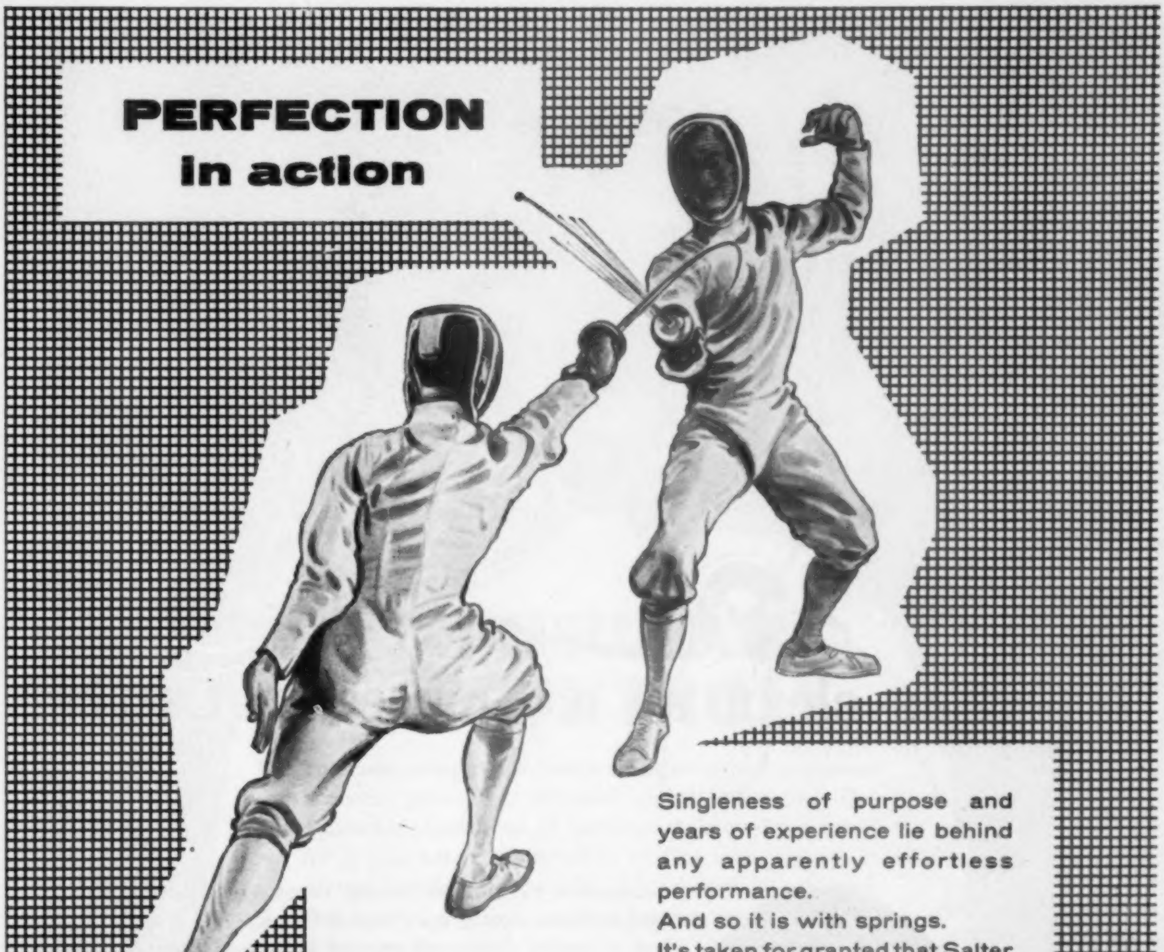
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Bearing bracket in Malleable Iron. Weight 3½lbs.

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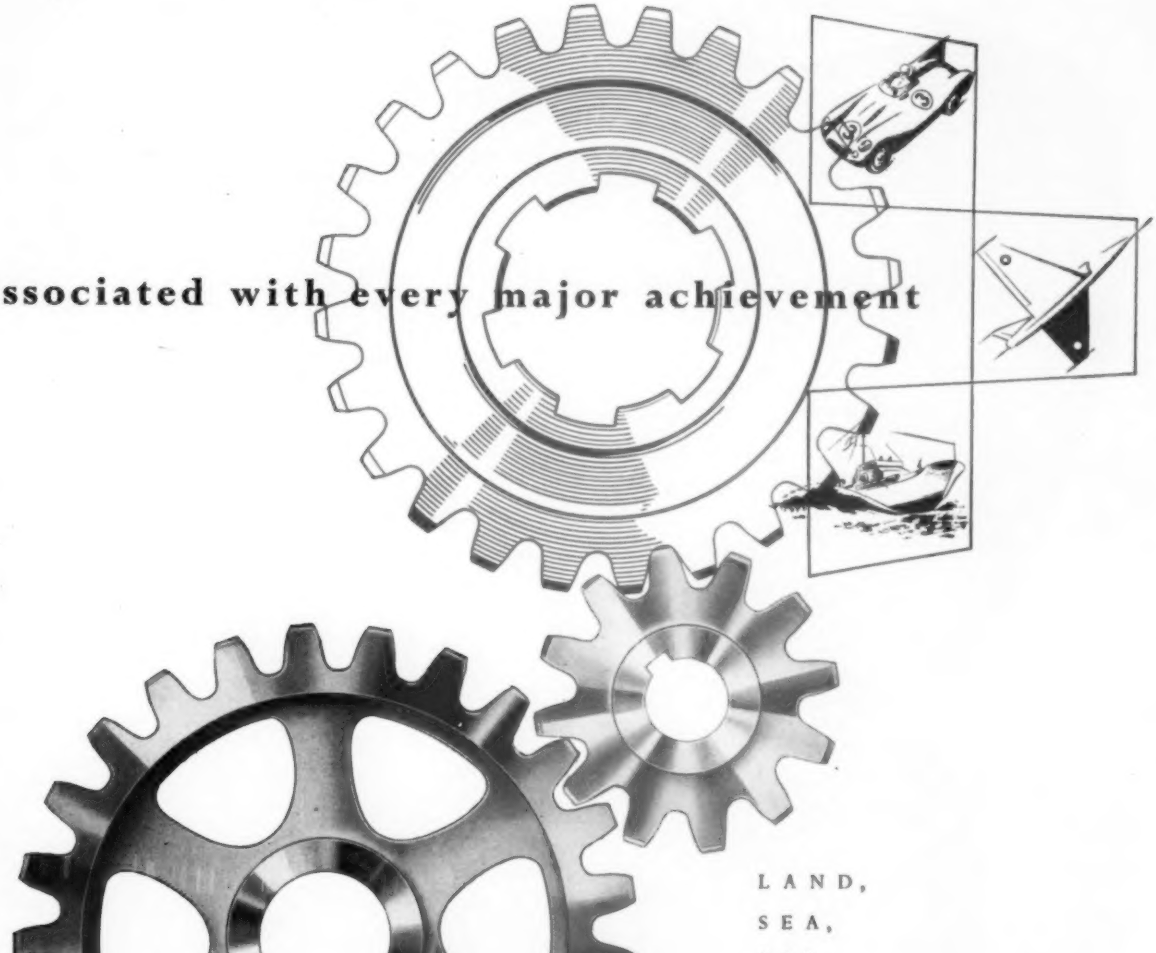

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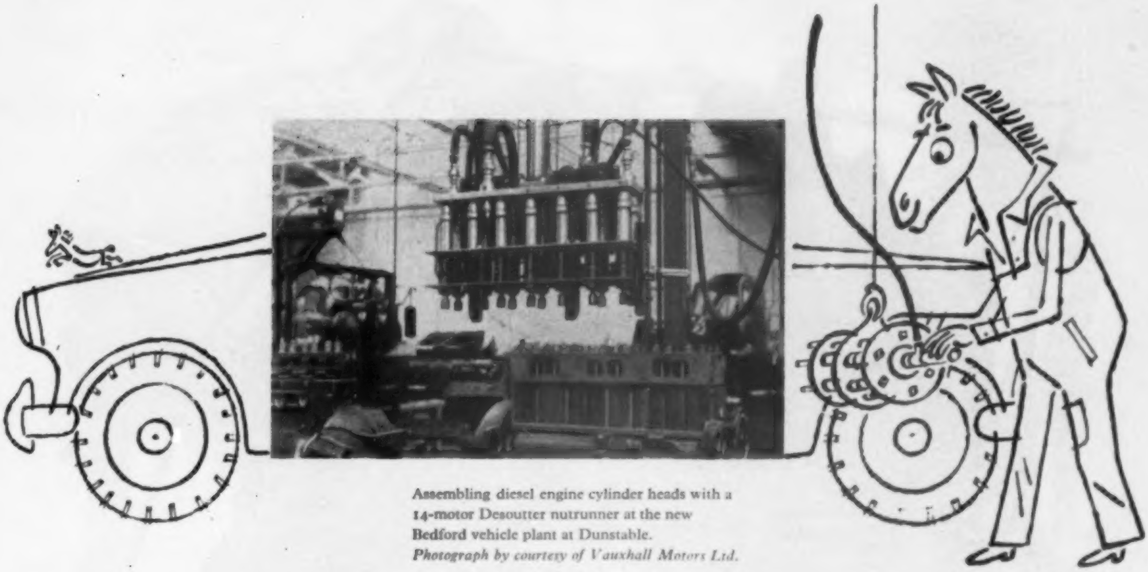

Assembling diesel engine cylinder heads with a 14-motor Desoutter nutrunner at the new **Bedford** vehicle plant at Dunstable.
Photograph by courtesy of Vauxhall Motors Ltd.

Desoutter in the Motor Industry

Without Desoutter power tools there would be no mass production. You may disagree, but that's *our* story and *we're* sticking to it. Come to think of it, do you know anything as fast, as reliable, as *non-stop* as a Desoutter power tool? Neither do we.

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A six-motor multiple nutrunner used on the wheel assembly of Ferguson tractors.
Photograph by courtesy of Standard Motors Ltd.

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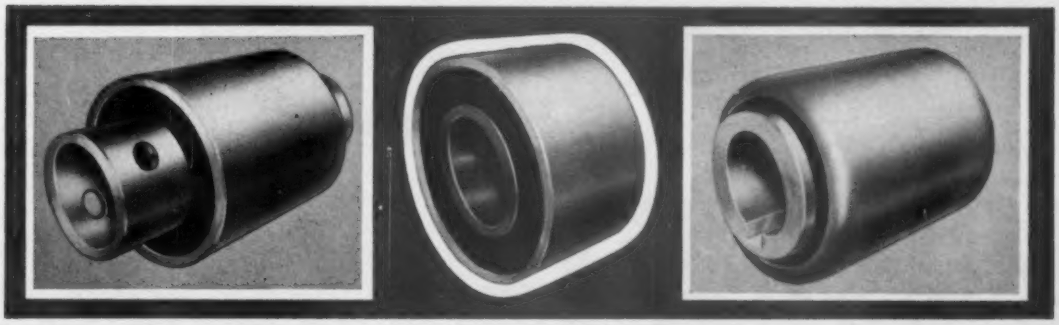

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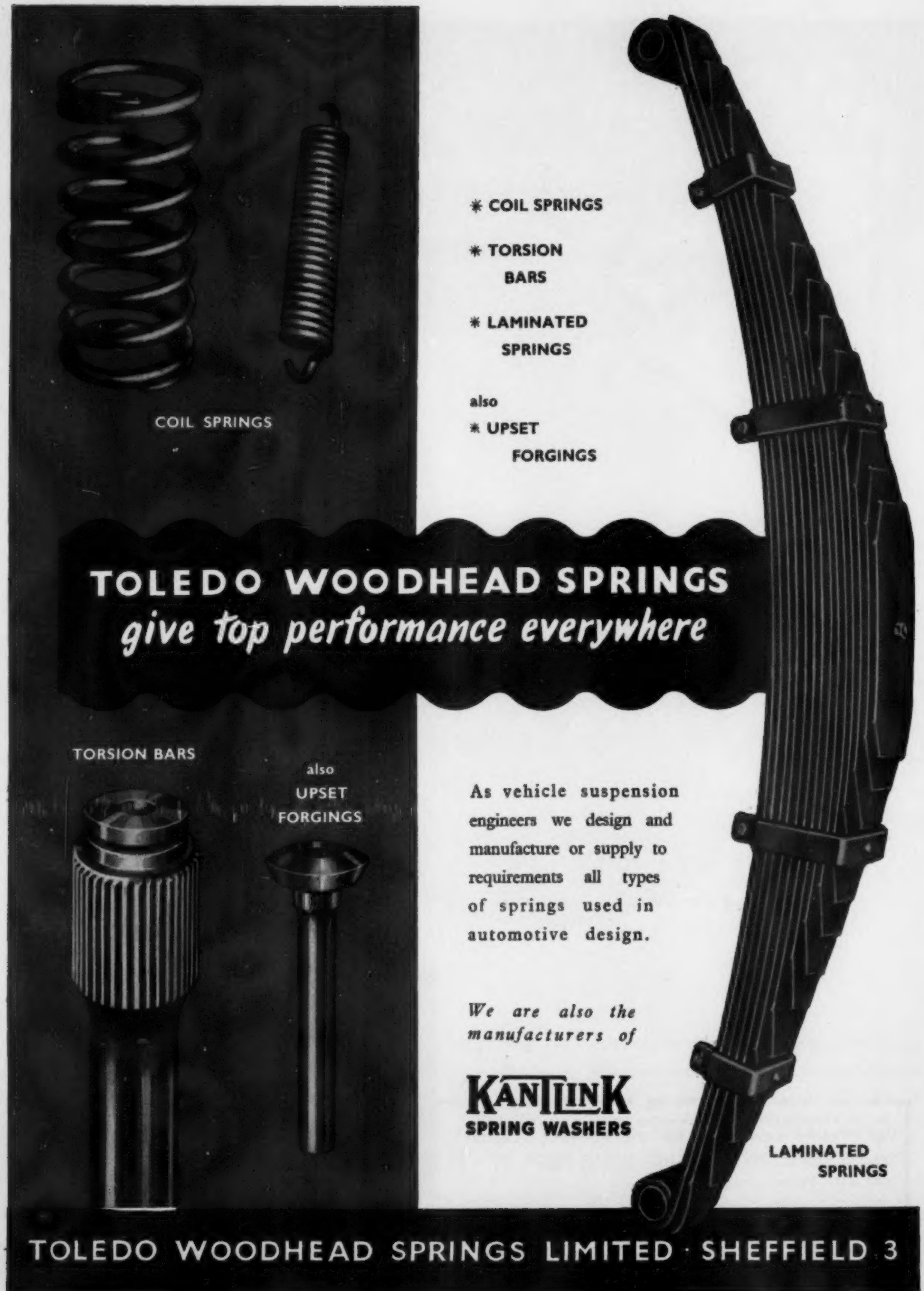
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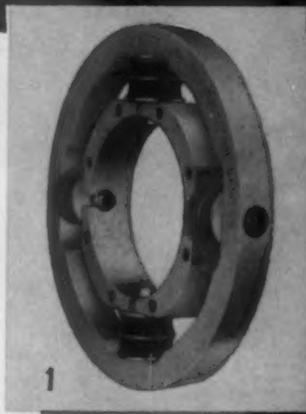

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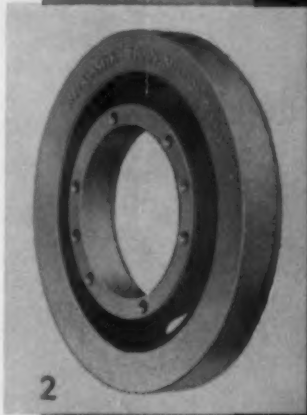

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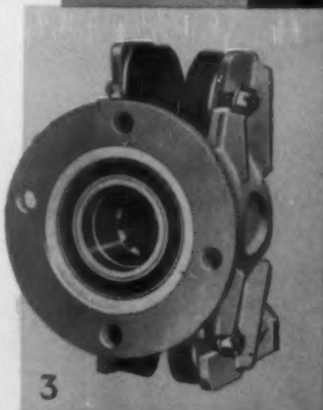

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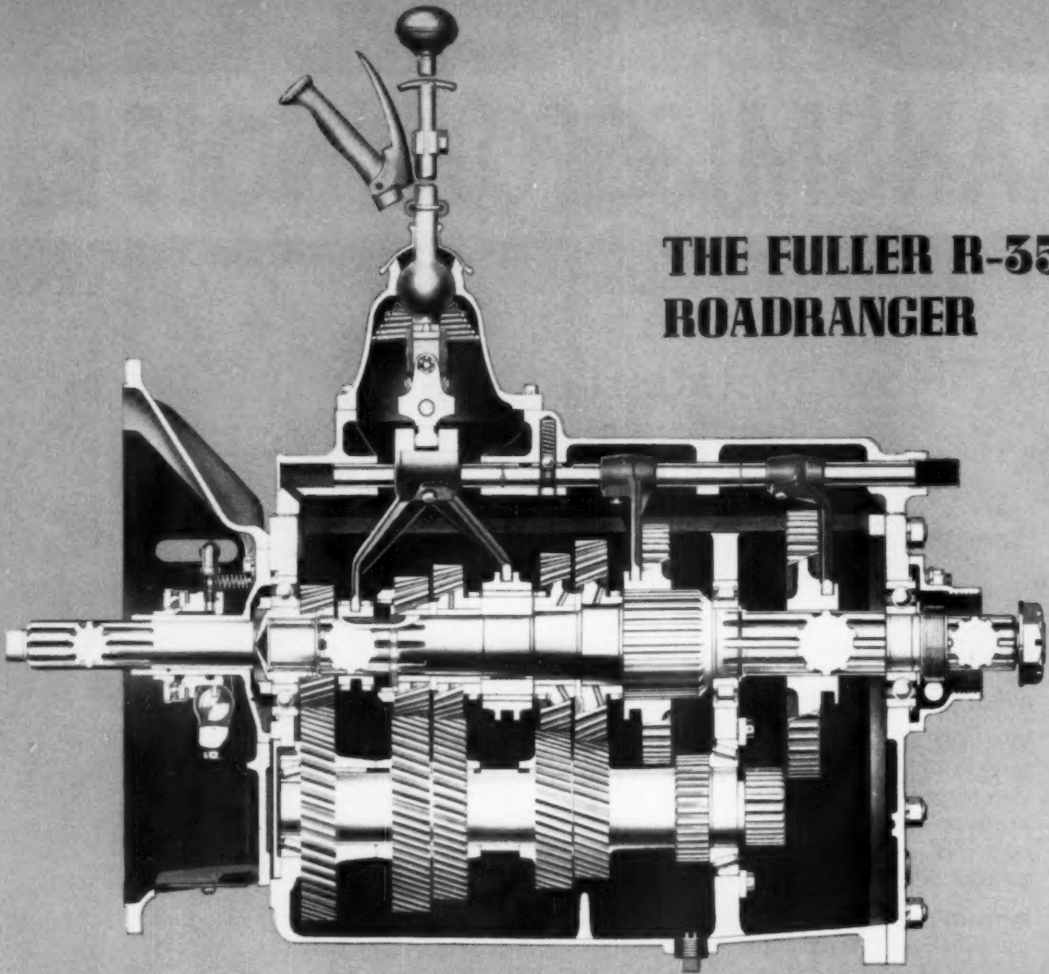

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Shown below:— The International V-195-A tractor incorporating Fuller R-35 ROADRANGER engaged on lumber haul.

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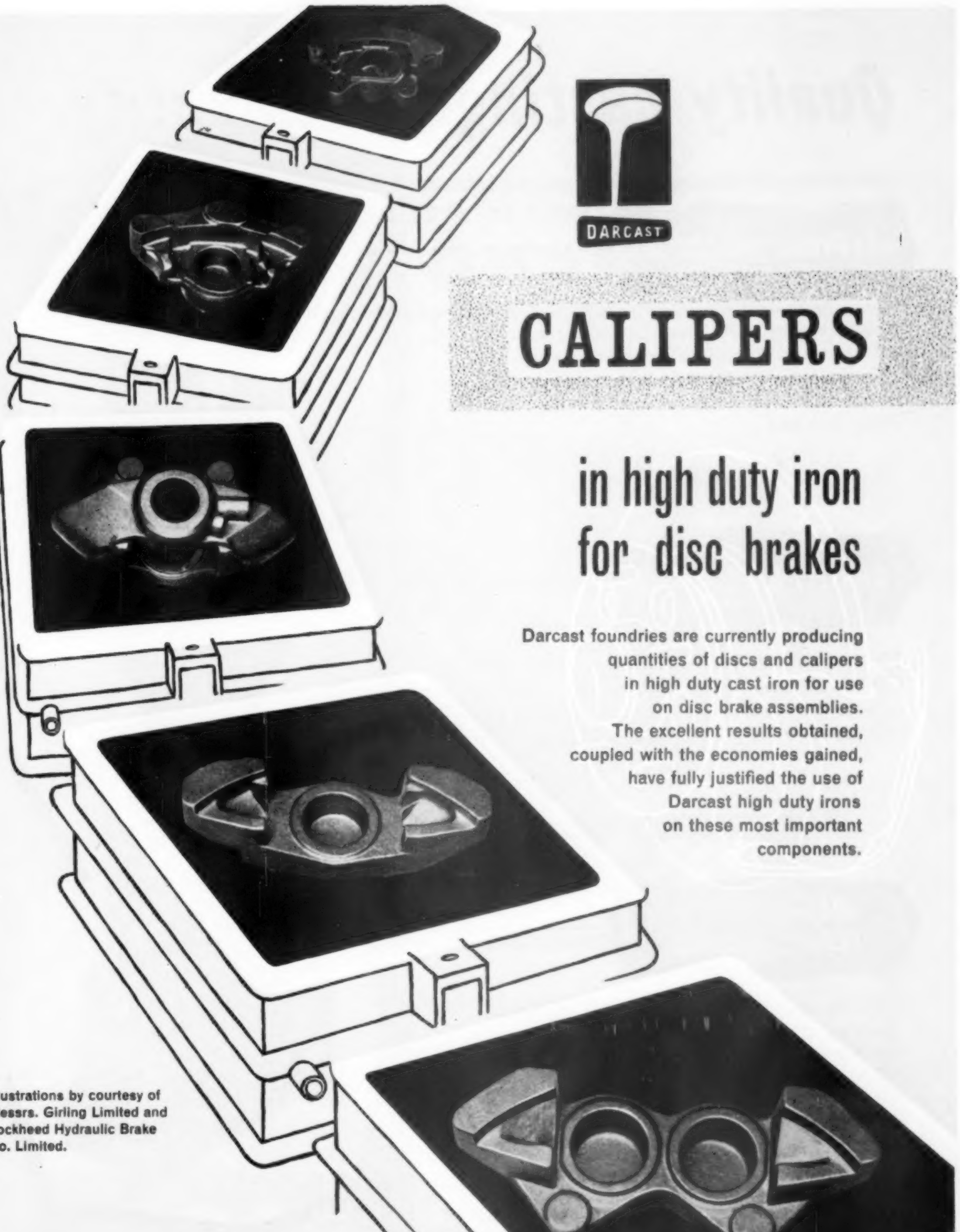

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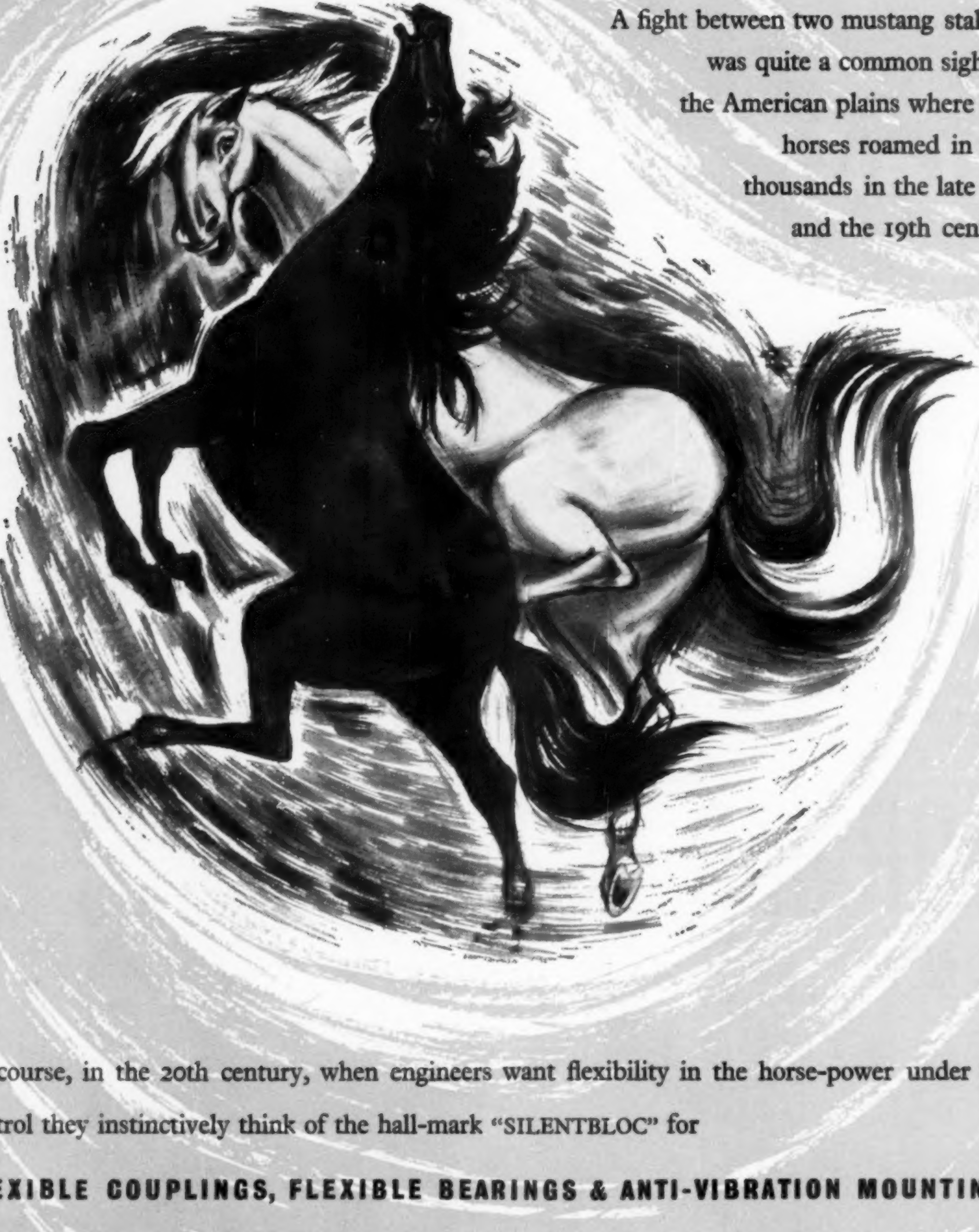

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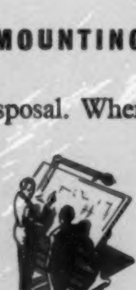

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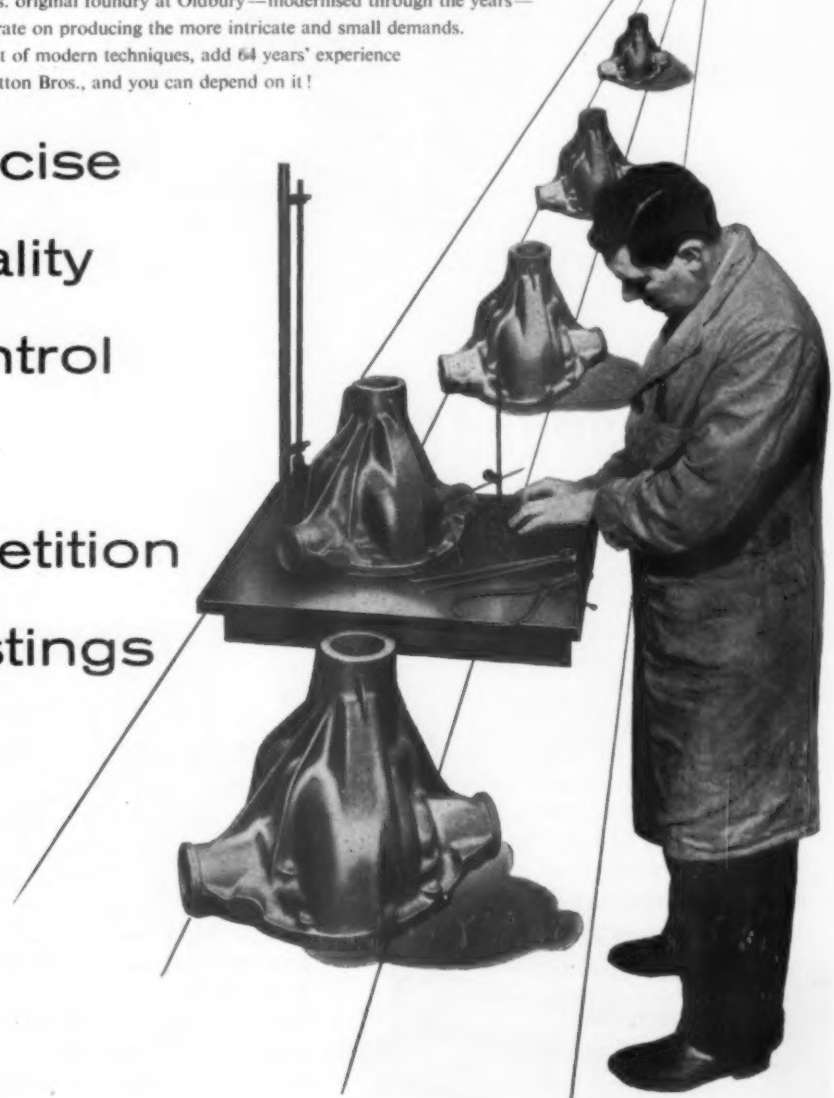

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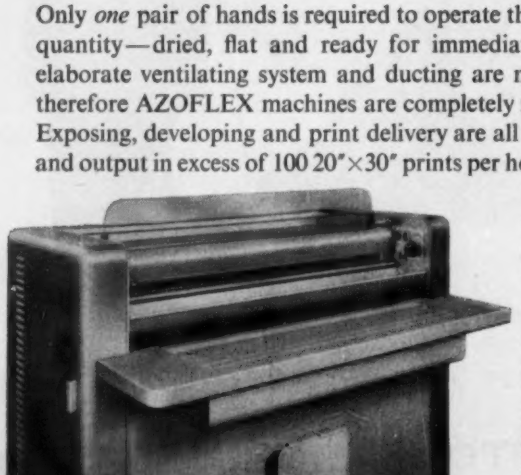

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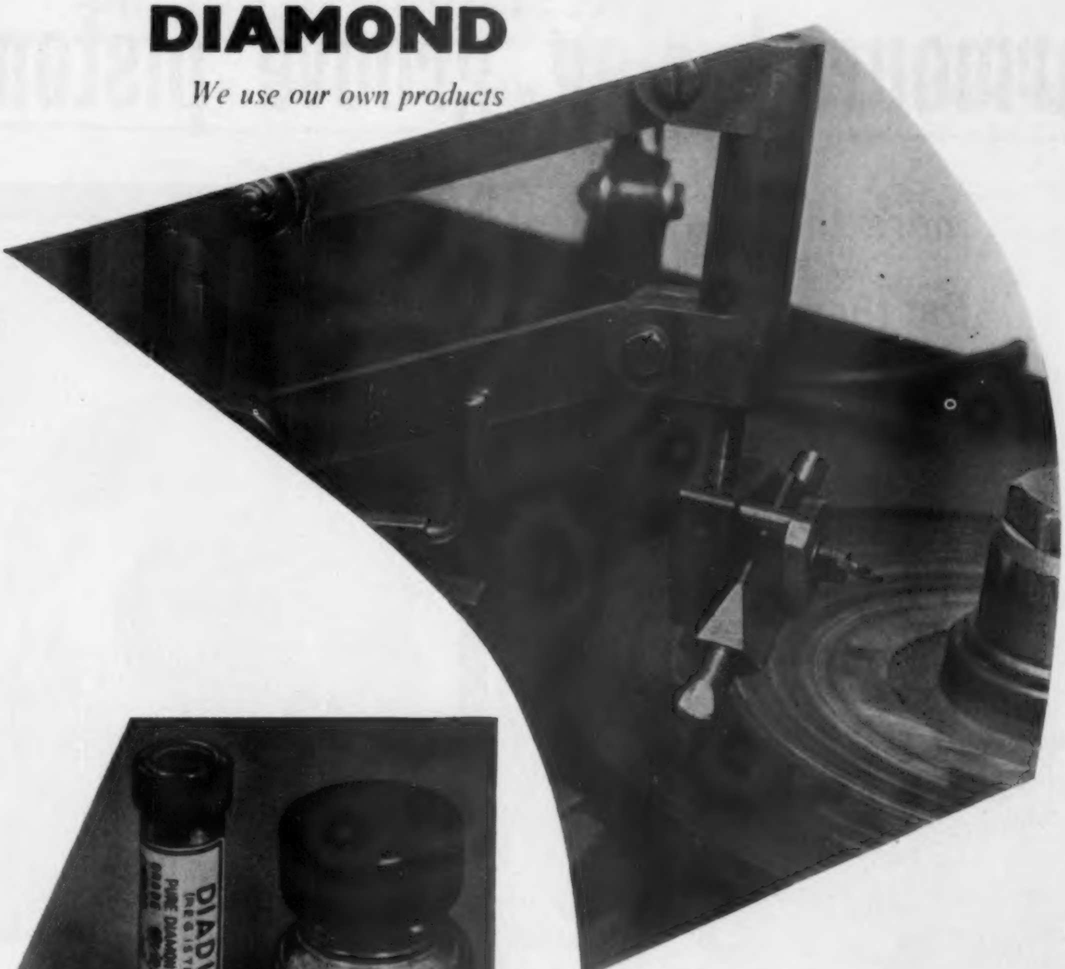

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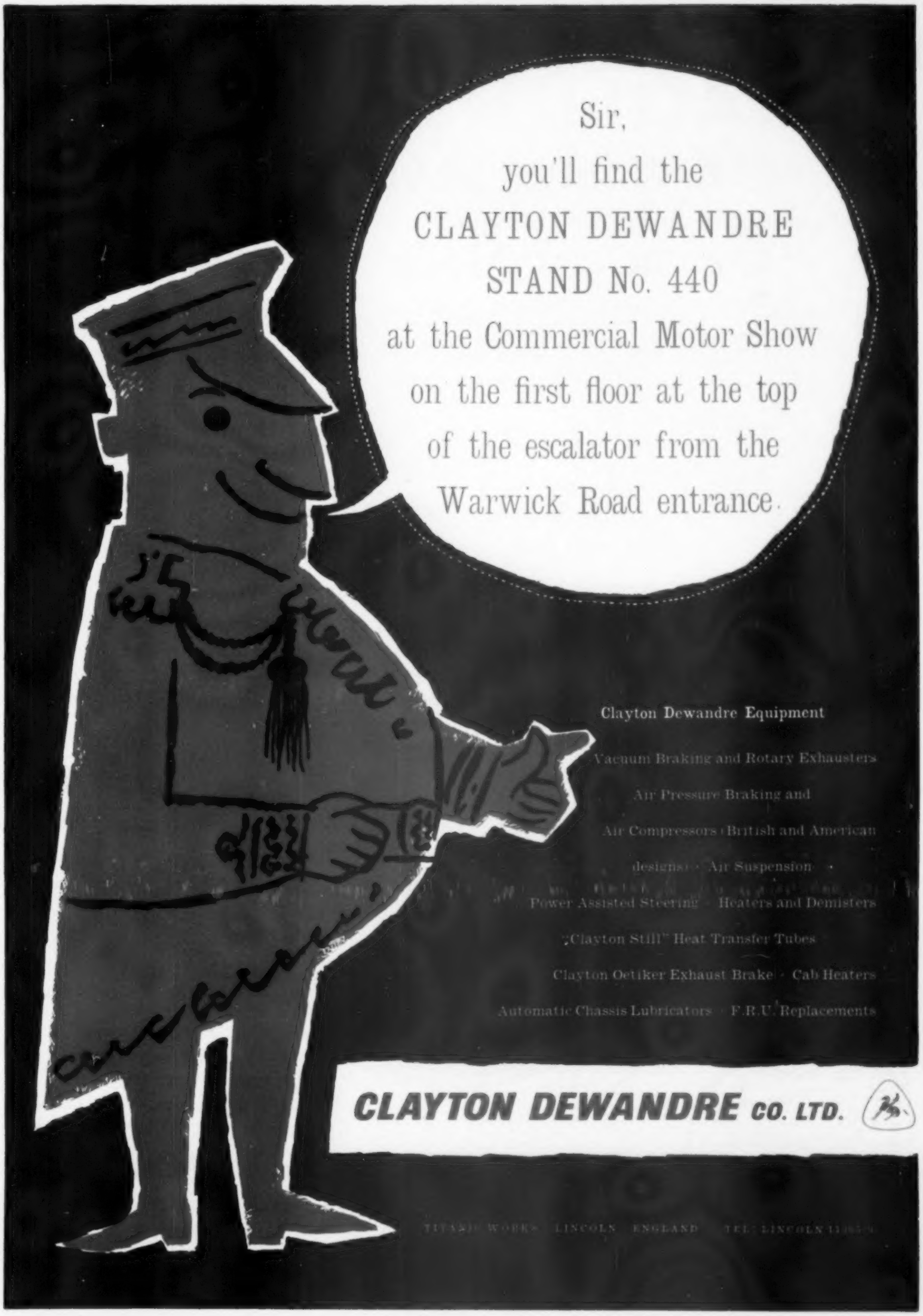
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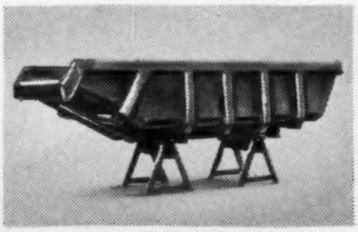
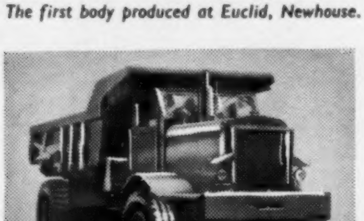
22 ton Euclid Rear Dump being loaded by large mechanical shovel.



The first body produced at Euclid, Newhouse.



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AUTOMOBILE ENGINEER

CONTENTS

PLYMOUTH 1958, V-EIGHT ENGINE, THE PRODUCTION OF WHICH IS DESCRIBED IN THIS ISSUE. SEMI-AUTOMATIC ASSEMBLY IS ONE OF THE NOTEWORTHY FEATURES OF THE MANUFACTURE OF THIS ENGINE

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Editorial Staff F. C. Sheffield (*Associate Editor*)

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Road Safety and Design

CURRENT trends in the United States of America and certain countries in Europe indicate that design features conducive to road safety are likely to be given increasing attention in all countries in the near future. One aspect of this subject, namely range of vision, was discussed in the July 1958 issue of *Automobile Engineer*. There are, however, a number of mechanical design features that also require careful attention.

One of the most fundamental considerations is that of weight distribution. If there is too much weight on the front end of the vehicle, the rear wheels are, of course, liable to lock when the brakes are applied; also, during acceleration, wheelspin may occur, again with the consequent danger of loss of control. On the other hand, if there is too much weight on the rear, the resultant tendency to oversteer may make the vehicle difficult to control accurately on corners. It is fundamental that the weight distribution cannot be left to chance in the design stage, and adverse effects of maldistribution corrected by alterations to the suspension and brakes during the development stage.

A great deal could be done by reducing the time lag in the actual application of the brakes. For example, systems by means of which the pedal travel is reduced almost to zero would reduce this lag considerably. The Maxaret anti-skid device, described in the July 1958 issue of *Automobile Engineer*, could be a noteworthy contribution to road safety, in that it reduces stopping distances under adverse road conditions and, even more important, enables the vehicle to be steered satisfactorily under maximum braking conditions.

With regard to lighting, there are several features that could be adopted more widely. Accessibility, for maintenance, and ease of alignment of headlamps are important, and measures to avoid changes in alignment with variations in load require more attention. Too many vehicles on the road have defective rear lamps. This condition could be mitigated by the employment of long-lasting bulbs. Lamp switch arrangements could in many cases be much more conveniently placed: there is a great deal to be said for having the headlamp switch on a pedestal on the steering column, so that it is close to the finger tips of the driver, and therefore can readily be used for signalling.

Since fatigue of the driver tends to cause accidents, seating comfort is an important consideration; it is also valuable from the point of view of sales appeal. So far, there is no indication that seat belts will be widely in demand in the near future, but if they are fitted, they should be adequately anchored to the floor, so as to hold both the driver and the seat. Even if drivers do not use the belts on short journeys, they might be persuaded to do so on long ones; this would probably be a useful advance in view of the fact that fatigue on prolonged driving at high speeds may impair judgment.

There has been a noticeable increase recently in the tendency for manufacturers, particularly on the Continent and in the United States, to fit crash pads on dash facias and waist rails. This is a useful feature, provided the padding used is effective. If, for example, soft sponge rubber is employed, there is a tendency for the part of the body that hits it to crash straight through the rubber and strike the hard backing with practically undiminished force. The firmer materials, such as cork or even perhaps the harder mixes of rubber, are more suitable for this purpose. In the design of a crash pad, an important consideration is which part of the body will hit it: obviously, a softer padding is needed for protecting the face than for most other parts of the body. The Road Research Laboratory, at Slough, is studying this among many other design problems concerning safety.

A wide variety of safety steering wheels has been introduced recently. The dished type is favoured in America but, like the others, it can only be satisfactory provided the spokes and rim are flexible enough to soften the blow if they are struck by the chest of the driver. On all types the hub should be of large area with smooth contours.

The controversy concerning the relative merits of laminated and toughened glass has not yet been settled. With laminated glass, the danger is that if the occupants' heads strike it, the glass may crack, but will offer considerable resistance to deformation, and severe cuts and lacerations may be sustained. On the other hand, if toughened glass is fractured, the fragments into which it breaks have rounded edges, which cause no more than minor scratches; moreover, if this type of glass is struck violently by any part of the occupants' bodies, it breaks up completely and offers very little resistance. The main disadvantage of toughened glass is, of course, that visibility is seriously reduced when it is shattered but remains in the frame. This disadvantage can be largely overcome if the glass is manufactured in such a way that when it is fractured the particle size is no smaller than 10 per inch, but this is difficult to obtain in practice.

Two specially treated forms of glass have been developed to obviate this disadvantage. One is the Visurit glass, in which a small circular panel in front of the driver remains undamaged if the remainder shatters. The other type is the Bisecurit glass, which is toughened in such a way that if it is hit by a stone, the damage is confined to only one half, either to the left or the right of the vertical centre-line of the glass. The disadvantage of both these types, so far as crash injuries are concerned, is that the portion that remains clear has jagged edges and is relatively heavy.

The Austin Gipsy

Part I: Cross-Country 4 by 4 Vehicle that has Independent Suspension, With Rubber Springs, at the Front and Rear

NOWADAYS the amount of data and experience available to the designer is such that the actual performance of the end-product normally approximates very closely to that estimated at the drawing-board stage. Consequently, a vehicle that not only exceeds the wildest hopes of the designers, but also proves their misgivings on certain features of design to be unfounded, is sufficiently unusual to deserve close study. Such a vehicle is the Austin Gipsy. That it has developed in this way is certainly not an adverse reflection on the designers, because the field of off-the-road operation is a highly specialized one that so far is as sparsely charted as the territory over which the vehicles are intended to operate.

Apart from the basic features — four-wheel drive and independent suspension all round — there is little in common between the Gipsy and its predecessor, the Champ, which was described in the September and October 1955 issues of *Automobile Engineer*. Originating in a Ministry of Supply specification, the Champ was produced to a requirement rather than to a price. Consequently, although its performance on military duties was admirable, it did not find ready acceptance in civilian markets. Besides being relatively costly to manufacture, the Champ was not easy to service. Routine maintenance included attention to a large number of lubrication points, and elaborate sealing of all moving parts was necessary in view of the conditions in which the vehicle was expected to work.

In the course of development work in conjunction with the Fighting Vehicle Research and Development Establishment at Chobham, Austin technical representatives had ample opportunity to observe the cross-country performance of trailers equipped with Spencer Moulton Flexitor rubber-in-shear, trailing arm type suspension units. Consequently, when their thoughts turned to the production of a successor to the Champ, it was natural that they should give serious consideration to the use of such suspension units on a powered vehicle.

Obvious advantages of the Flexitor suspension system were extreme simplicity of construction, complete absence of the need for maintenance attention, and relative indestructibility. Set against these was the lack of experience of the behaviour of this type of suspension in connection with the functions of driving, braking and steering. On paper the attractions of the single trailing arm, located entirely by a non-rigid medium and bearing the stresses of brake torque reaction, were to say the least of it, questionable. It was evident that both courage and foresight would be needed to face these difficulties.

Although the possibilities of rear steering effects of the trailing arm suspension had to be faced, it was the front end that gave rise to the most serious misgivings. In theory, brake torque reaction was the major problem. It was expected that this, coupled with the inevitable forward weight transference due to deceleration, would cause uncontrollable diving. To overcome this, it was proposed that advantage should be taken of the presence of the front wheel driving shafts to mount the brakes inboard. Since one of the primary aims of the design was that the greatest possible number of components and assemblies should be common to both the front and rear assemblies, this would have involved also the use of inboard rear brakes. At this point a legal snag was encountered, inasmuch as the Construction and Use regulations expressly prohibited inboard braking for all four wheels. Furthermore, the same regulations in effect prohibited inboard brakes for the front wheels of a goods vehicle weighing more than one ton unladen. Although the regulations were subsequently relaxed to allow inboard brakes on two wheels of goods vehicles weighing up to 30 cwt unladen, the provision regarding front brakes of vehicles remained entirely unaltered.

A further attraction that all-round inboard brakes would have offered, apart from a reduction in unsprung weight, was the facility they would have provided for the fitting, as an alternative to the standard tyre equipment, of very large section, flotation tyres on small diameter rims, without consequent limitation of the brake drum diameter. In the face of the legal obstacle, however, all these considerations had to be abandoned, and the vehicle was put into production with normal four-wheel braking. It was, therefore, with some surprise and considerable relief that the Austin engineers found that in practice none of the unpleasant braking effects that they had feared actually manifested themselves during the extensive development testing that has been carried out.

DIMENSIONS AND WEIGHTS

	ft	in
Wheelbase	7	6
Track: front	4	6¾
rear	4	4
Overall length	11	7
Overall width	5	6¾
Loading height	2	2½
Height to top of steering wheel	4	8½
Interior: width over wheel arches	4	10⅞
width between arches	3	1
height of wheel arches		9
length of floor	4	7⅞
height of body sides	1	5
body capacity	23½ ft^3	
Maximum gross vehicle weight	40 cwt	
Dry weight: petrol	24 cwt	
diesel	25¼ cwt	

As is to be expected on a short wheelbase vehicle in which the rubber suspension medium inevitably allows a small, but nevertheless measurable, amount of give, and in which the castor angle varies widely from positive to negative under spring deflection, the steering characteristics are not comparable with those of a sports car. For a cross-country vehicle, however, this is of negligible significance compared with the fact that, even on the roughest going, there is no kick-back at the steering wheel. This is a valuable factor in reducing driver-fatigue.

Apart from the suspension, which is the most unconventional feature of the design, the chassis is remarkable for its rugged simplicity and for the attention which has been paid to the reduction of maintenance operations. Wherever possible, standard components are used, and the front and rear final drive units are identical. Unified threads are used

CHARACTERISTICS OF THE RUBBER SUSPENSION UNITS

	Front	Rear
Loading per unit, laden (approx.)	730 lb	940 lb
Periodicity (approx.)	115 c/min	125 c/min
Axial stiffness	18,000 lb/in	22,000 lb/in
Radial stiffness	140,000 lb/in	156,000 lb/in
Resistance to tilting	40,000 lb/deg	56,000 lb/deg
Tilt (normal loading)	½ deg	¼ deg
Centre-to-centre length of trailing arms	13 in	13 in
Wheel movement at 5 cwt load, each: bump	3·0 in	4·0 in
rebound	2·9 in	2·9 in

throughout the chassis, body and transmission, but the petrol engine, being of an older design, has not yet been altered, and still has B.S.F. threads.

Suspension

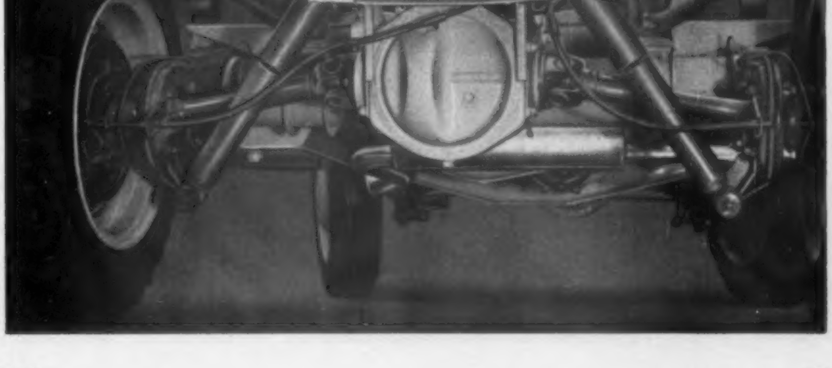
The employment of rubber in torsional shear, to serve both as the suspension medium and the wheel location, limits the choice of layouts: the trailing arm is clearly the most practicable type. This is the layout on which the original development work on trailers was done. The front and rear suspension units are similar in principle, differing only in detail.

A 2¾ in diameter tube, to which a rubber sleeve is bonded, forms the main torsion member of the suspension unit. This assembly is housed in a shell, which in effect is a tube made in two halves. The lower half of the shell is in the form of a deep trough, to which the rubber is also bonded; its upper half, with its edges turned upwards, is placed over the rubber and pressed downwards until the upturned edges mate with the edges of the lower trough. These edges are then spot-welded together, so that the rubber is preloaded. As can be seen from the figures in the Table, the resultant precompressed rubber bush assembly allows so little relative radial and axial deflection between inner and outer members that for all practical purposes this movement can be disregarded. The effective length of the front bushes is about 14½ in, and of the rear about 16 in. In its finally assembled form the rubber sleeve is about ⅝ in thick. One end of the central tube projects, and to it is welded a flange in which are tapped holes for the attachment of the trailing arm. A small spigot on the flange locates the arm.

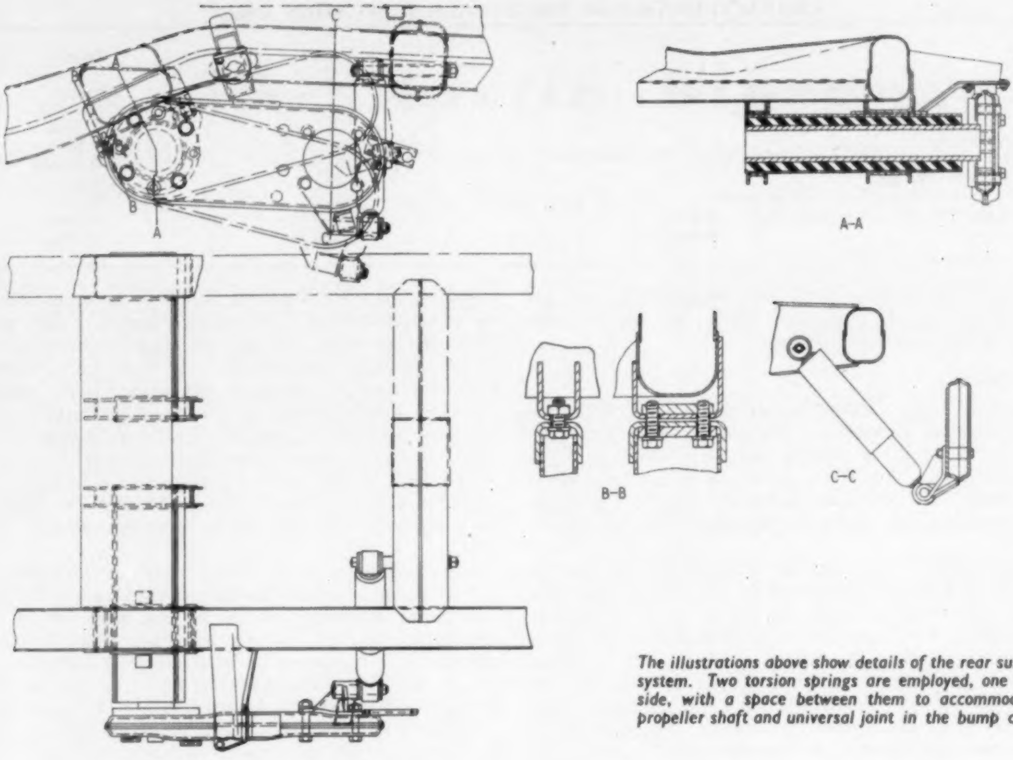
Two shallow oblong, dished pressings of $\frac{5}{32}$ in thick En2 steel, are welded together round their edges, to form the suspension arms. The complete assembly is about 7 in deep and has an average thickness of about 1½ in at the ends, increasing slightly towards the middle of the arm to increase the torsional stiffness. The effective length of each arm is 13 in between centres. To prevent compression and collapse of the hollow pressing by the attachment bolts, distance-pieces are inserted. These are tack-welded to one pressing, and then, after assembly, tack-welded to the other through the centre opening. At present the arms are machined flat on their attachment faces. To avoid reduction in the thickness of the metal at this point a modification is being adopted whereby the distance-pieces project through the casing on the attachment side, and can be faced off just clear of the casing.

Additional holes in the forward ends of both front and rear arms, and additional tappings in the attachment flanges, provide an alternative setting for the arms whereby the ground clearance can be increased by 1 in. This provision is intended purely to cater for special operating conditions; it is not an adjustment to compensate for initial settling of the rubber, which in practice does not occur. The front suspension arms are cranked about 2½ in, in plan, to allow adequate steering lock, while at the same time keeping down the mass and overhang of the swivel housings. Rectangular holes pierced in the centres of the arms allow clearance for the track rod. The edges of the holes are sealed by closing plates which contribute to the torsional stiffness although, being round the neutral axis, these openings do not affect this feature very much.

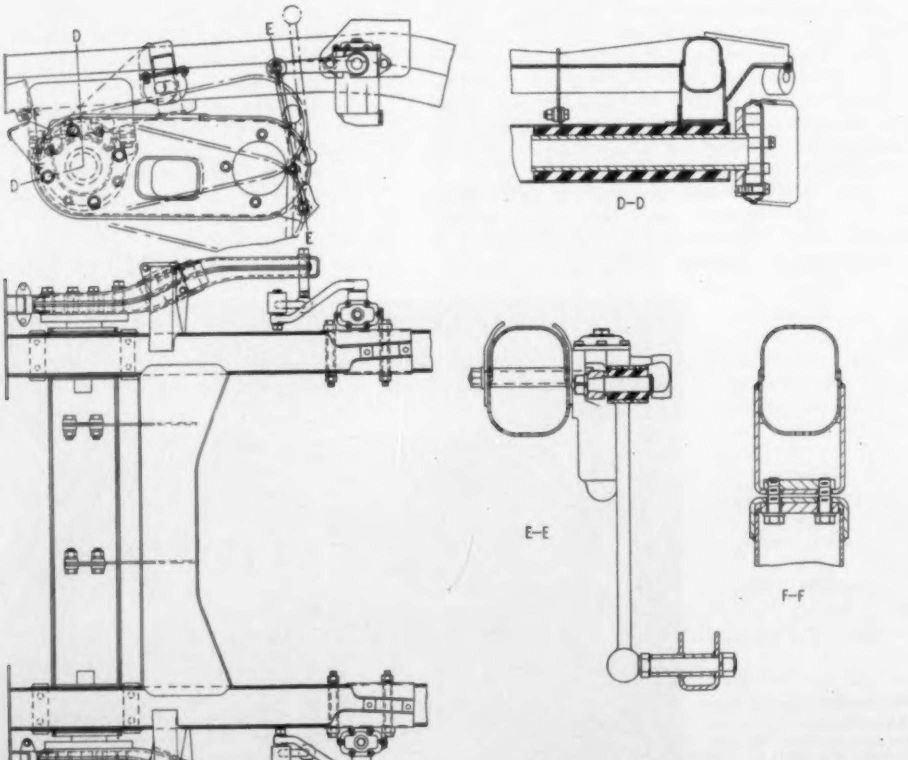
Since rubber in torsional shear has an almost linear rate, an appreciable measure of progressive springing is provided by the bump stops, which are also a Spencer Moulton product. These stops are in the form of thick rubber rings bearing on plates welded to the upper edges, midway between the centres, of the arms. The first stage of compression closes the hole in the ring, after which further compression is resisted by resilient solid rubber as with a conventional bump stop.



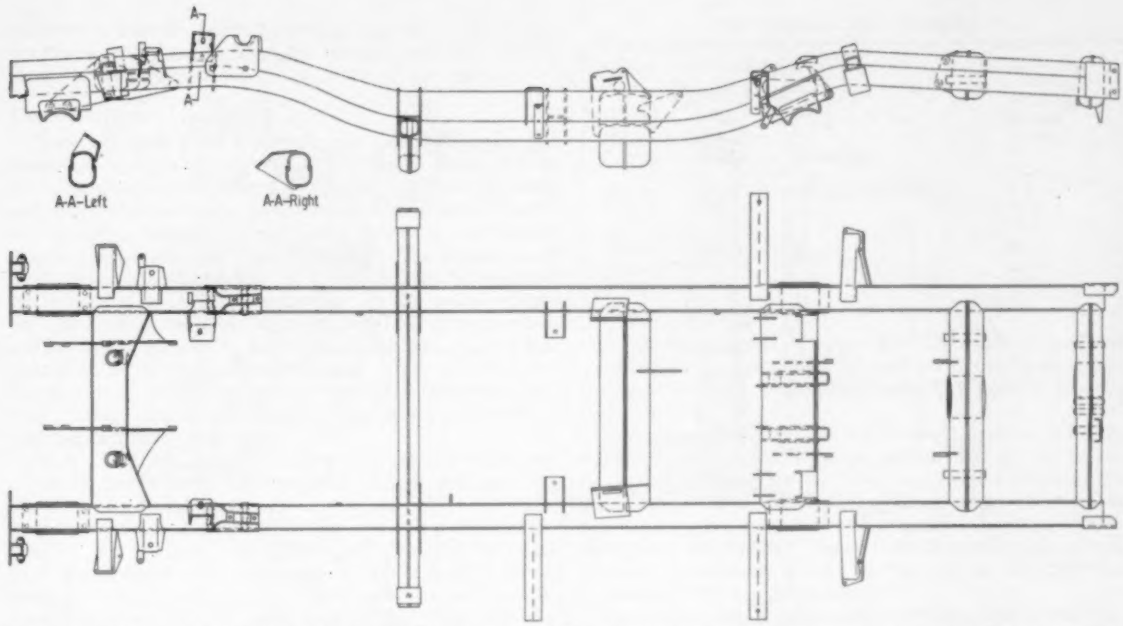
Although the self-damping properties of the rubber springs relieves the shock absorbers of some of their work, large telescopic units are used at the rear to ensure satisfactory riding performance on rough terrain



The illustrations above show details of the rear suspension system. Two torsion springs are employed, one on each side, with a space between them to accommodate the propeller shaft and universal joint in the bump condition



On the front suspension, the two spring units are in a common shell, which forms an additional cross member



The lower half of the section of each side member of the frame is of uniform depth throughout its length, so that it can be produced by rolling

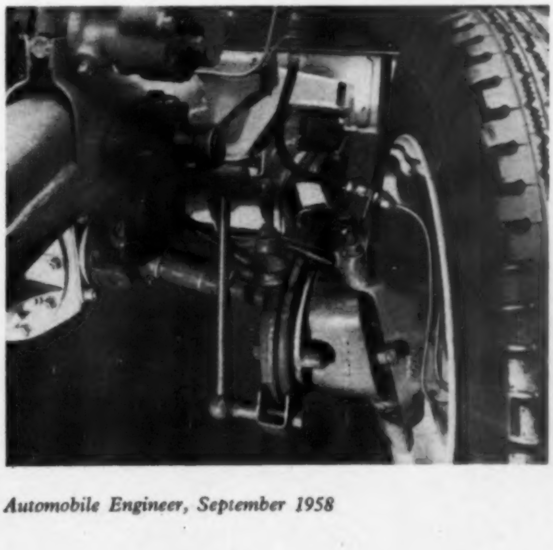
The self-damping properties of the rubber suspension relieve the shock absorbers of some of their work. Nevertheless, on rough country considerable heat is generated in the shock absorbers, and for this reason the lever type has been chosen for the front, because much of the heat can be dissipated through contact with the chassis frame. At the rear, telescopic dampers, with an internal diameter of 2 in, are fitted. Their length open is 17·37 in, and closed 11·32 in. To promote stability on corners they are transversely inclined at 45 deg. The shock absorber settings provide for most of the resistance to take place on the rebound stroke, very little bump damping being required.

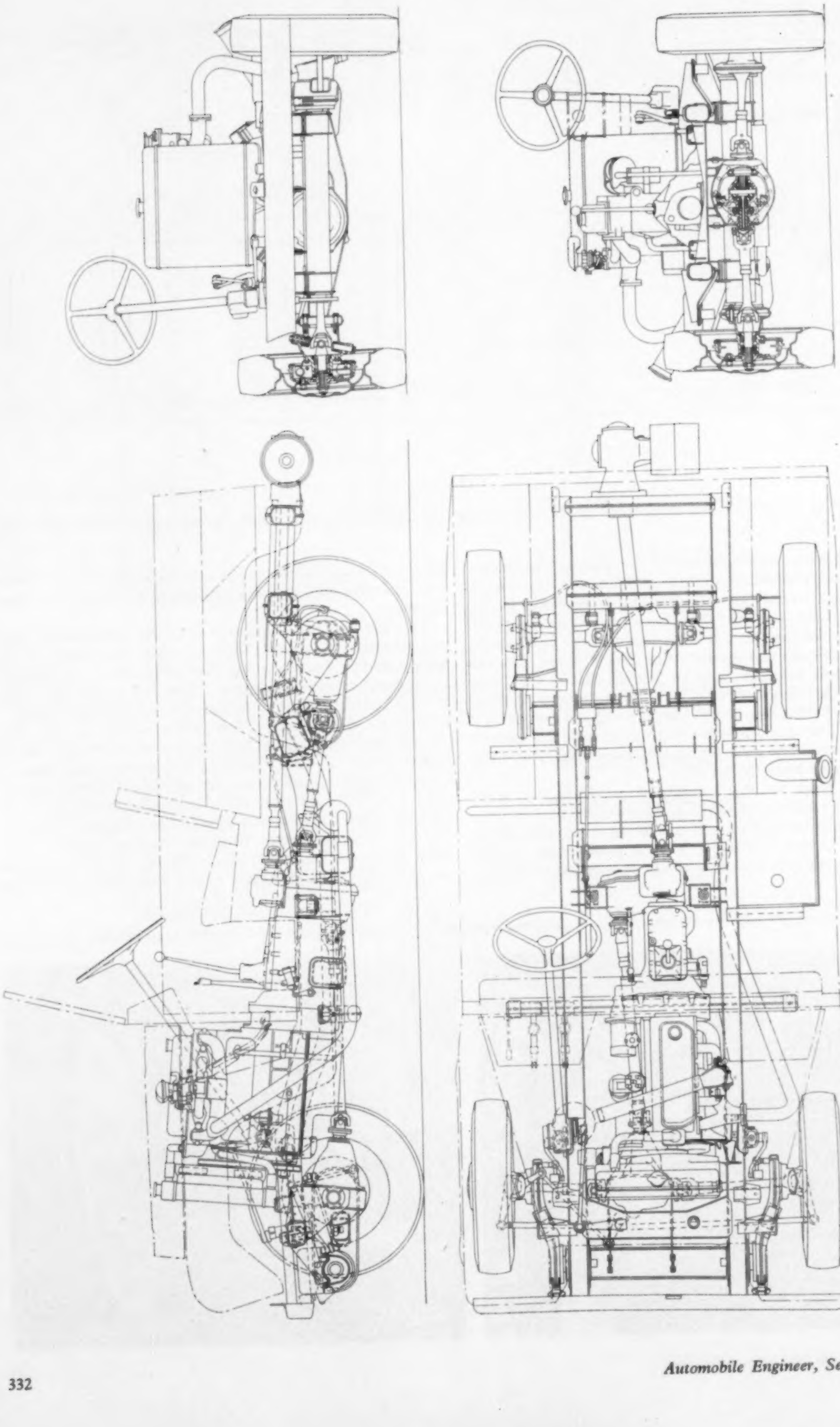
Rebound stops are not considered necessary, but it is important to avoid stressing the suspension, beyond the free position, in the event of the wheels leaving the ground either when the vehicle is running or when it is jacked up. Small stops are therefore provided on the front suspension arms to relieve the shock absorbers of this duty. At the rear, however, the telescopic dampers limit the free movement without damage.

The fact that the suspension is of the independent type, and therefore has a low unsprung mass, undoubtedly is an important factor so far as the successful use of the dampers as rebound stops is concerned. This low unsprung weight is also useful in respect of ride comfort over rough terrain.

Substantial channel section yokes, welded to the shell of each suspension spring unit, are bolted to brackets on the chassis frame. At the front the two spring units share a common shell, which forms an additional cross-member. This yoke and shell assembly is bolted below the main side members, and it contributes little to the torsional stiffness of the frame. At the centre, two plate brackets, welded to the front cross-member and bolted to the top of the shell, assist in taking the torsional loads of the suspension. The rear

The front suspension, showing how the trailing arm on each side is pierced to clear the track rod and cranked to allow adequate steering lock





GENERAL ARRANGEMENT OF THE AUSTIN GIPSY CHASSIS
Wheelbase 7 ft 6 in; track, front 4 ft 6½ in, rear 4 ft 4 in

suspension units are separate, leaving clearance at the centre for the propeller shaft. They are mounted directly below a main cross-member of the chassis frame of the vehicle.

Chassis frame

Since the body does not make any contribution to the structural strength of the vehicle, the chassis frame has to combine maximum stiffness in torsion and bending with reasonable lightness. An important additional requirement in view of the continuous hammering to which this type of vehicle can be expected to be subjected is the avoidance of local stress concentrations. A frame having box section side-members is obviously essential. In the initial design the halves of each side-member were welded along the top and bottom of the section, but it was found that, because the joins were along the lines of maximum stress, the slightest unevenness in the welding gave rise to cracks. Furthermore, such a design, with double-cranked side-members, involved relatively expensive pressings.

After considerable thought, a form of frame was evolved in which all the welding was near the neutral axis and the pressings were relatively easy to produce. The resultant frame has proved entirely satisfactory in service. Each side-member is composed of upper and lower U-section, 14 S.W.G., En2B steel pressings, the lower half being of uniform depth, $2\frac{3}{8}$ in, throughout its length, so that it can be produced by rolling; the crank radii of the lower sections, as viewed in side elevation, are subsequently formed by a simple pressing operation. As viewed in plan, both side members are straight. The upper section on each side-member varies in depth, from 4 in at the centre to 2 in at each end, and is produced entirely by pressing. The width of the lower section is 3 in, and the upper section, which is $2\frac{27}{32}$ in wide, fits inside it with a $\frac{3}{8}$ in overlap. The joints are made by continuous arc welding, and the ends are closed by plates, so that each member is completely sealed to prevent internal corrosion.

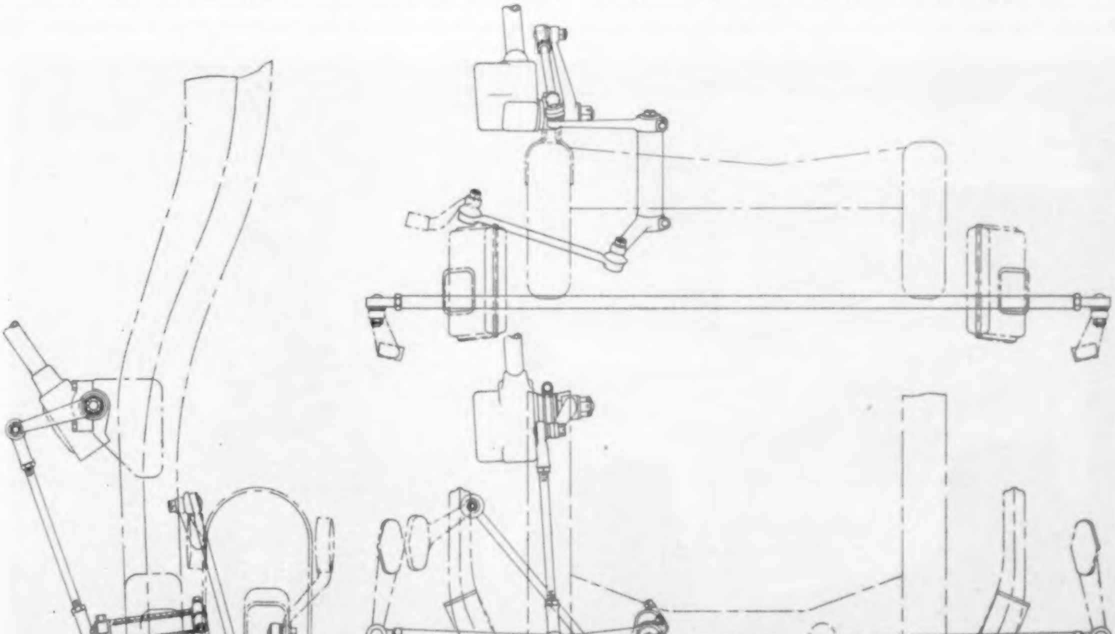
STEERING AND BRAKES

Castor: normal load	$+3\frac{1}{2}$ deg
full bump	—10 deg
free	+16 deg
Camber	$1\frac{1}{2}$ deg
King pin inclination	12 deg
Centre-point offset at ground, with 5·00 × 16 rim	$1\frac{1}{4}$ in
Wheel offset, with 5·00 × 16 rim	$1\frac{3}{16}$ in
Turning circle	37 ft
Steering box ratio	14·5 : 1
Drum diameter	10 in
Drum width	$1\frac{3}{4}$ in
Brake lining area	133 in^2

In section, the upper and lower components of the side-members are not a true U-shape, in that there is a flat on the $1\frac{1}{16}$ in radius base of the U. Thus in the region of maximum stress, that is, along the upper and lower edges, the metal is not worked, or preformed, and presents a uniform section throughout the length. The ends of all cross-members and brackets are extended to form lips that can be welded to the flat portion of the side-members.

There are, in all, six box section cross-members, each with clearly defined duties. The front member is of similar depth and section to the side-members, but in plan is broader and flared out towards the ends, for additional stiffness. It carries the brackets for the front final drive assembly and suspension unit, and the tubes that house the steering relay. The second cross-member, is at the point where the upswept front part

An unusual feature of the steering layout of the Gipsy is that it incorporates a two-piece drag link used in conjunction with a one-piece track rod



merges into the straight, deep centre portion of the side-members. It is carried below the side-members and bowed downwards to sweep under the transmission, and also is extended at the ends, to form outriggers for body mounting. Being unstressed torsionally, it is made from two top-hat section pressings welded together by their flanges, which are along the top and bottom of the completed section. Its attachment to the side-members is by two deep gusset plates, which are carried round and welded to the flat top surface of the side-members.

The third cross-member does not carry any components, but serves to strengthen the frame in the centre of the flat portion, where the fuel tank is carried on outrigger brackets outside the left-hand side-member. It is of rectangular section, welded along its top and bottom seams, and its ends are welded to the full depth of the inner faces of the side-members; lips at the top and bottom are welded to the flat upper and lower surfaces.

At the start of the rear upsweep of the frame is the fourth cross-member. This member carries the loads from the rear suspension, and shares with the fifth the loads from the rear final drive assembly. Beyond this point the frame is relieved of suspension stresses, carrying only the rear part of the body and dealing with towing stresses and the rear power take-off. The section of the fourth cross-member is rectangular, but its welded seams are at the sides. Its attachment to the side-members is similar to that of the third cross-member.

The fifth cross-member, which is just behind the axis of the rear axle, carries the main load of the final drive, and the rear shock-absorber mountings. At the extreme rear, the sixth cross-member carries the power take-off unit, if this is fitted. Both members are of similar construction, seam-welded at top and bottom, and pierced towards the right-hand side for the power take-off shaft. The rear cross-member is reinforced, to take towing loads, by a horizontal flat plate located inside the section, midway between the top and bottom, and extending from the power take-off opening to the left-hand end of the member. The plate is tabbed to fit into slots pierced in the front and rear pressings of the cross-member, and welded after assembly of the pressings. Unlike the side-members, the cross-members do not have overlap joints. Instead the edges are turned out slightly to form shallow grooves for internal welding.

All brackets for the front and rear bump stops, front and rear body mountings, fuel tank and engine mountings, are well gusseted. The mountings for the front shock absorbers are reinforced by plates welded to both sides of the lower half of each side-member. The plates are extended upwards, swept inwards and shaped to receive the steering box trunnion, whichever side it is fitted. Tapping blocks are welded between the plates.

A feature of the chassis design is the liberal use made of tapped holes in components, or tapping blocks welded to sheet metal parts. This eliminates a large number of loose nuts, and probably saves considerable time on assembly and wastage in respect of bought-out parts. Another feature of the general layout is the high degree of protection to vulnerable parts afforded by substantial chassis members. The engine sump, particularly, is well out of harm's way, being more than 12 in from the ground at its lowest point and protected in front by the mass of the forward final drive assembly. Just behind the sump, the second cross-member extends to within 9 in of the ground and ensures that the vehicle cannot ride on the sump. A separate sheet metal guard is fitted under the fuel tank, which is also protected to some extent by the body skirt.

Steering

Unusual inasmuch as it consists of a two-piece drag link and a one-piece track rod, the steering linkage is as interesting as the unconventional suspension and chassis layout. The steering column is reasonably short, so the steering box is

The body of the Austin Gipsy has a hinged tailboard and a flat floor, with the boxed wheel arch extending the full length of the rear compartment

mounted some 10 in behind the axis of the front axle. An inverted drop arm is connected to a relay lever by a longitudinally arranged rod approximately 14⅝ in long, as measured between ball joint centres. This relay lever is carried at the upper end of an almost vertical shaft, and a second lever, at the lower end, is in turn connected by a diagonal rod to the steering arm on the swivel housing, the steering arm being at about 45 deg to the axle centre-line. The length of the diagonal rod, the ball centres of which are fixed at 15⅜ in, is equal to the distance from the ball joint on the steering arm to the centre-line of the suspension pivot. On the relay lever, the ball joint works in a plane slightly above this centre-line, and the diagonal arrangement reduces the error due to spring deflection on either lock.

The longitudinal rod is right- and left-hand threaded for adjustment, but the diagonal rod is integral with its ball sockets. The one-piece track rod is tubular, being threaded internally to receive the right- and left-hand threaded shanks of the ball joints. It is carried in front of the axle, and the true Ackermann geometry is maintained by splaying the levers outwards. The rod passes through the suspension arms and is kinked ¾ in at the centre to clear the final drive housing on full lock. In service this kink is perfectly satisfactory, but it is regarded as an unfortunate expedient because owners of the vehicles have been known to straighten the rod, thinking it had been bent accidentally, with disastrous results to the wheel tracking. A further disadvantage is that nothing less than a full turn can be given to the rod for track adjustment. A modification is being carried out to allow a straight rod to be used although, since the steering arms have been brought out to the limit of clearance for the smallest and widest rims fitted, a slight departure from the true Ackermann will be involved. In practice this would probably be a small price to pay for a straight rod.

In the layout of the steering, the factor limiting the lock angles is the angular movement allowed by the driving shaft outer universal joints. Since Ackermann geometry calls for a wider angle of turn of each wheel outwards than inwards, it has been possible to gain an extra 4 deg of lock angle by offsetting the front final drive unit, with its axis ⅞ in forward of the axle centreline.

The steering gear itself is of the simplest cam and lever type, with a ratio of 14·5 : 1, which gives a movement from lock to lock with slightly more than three turns of the steering wheel. All six ball joints are nylon bushed, requiring no lubrication during their life. Hanging ball joints — anathema to the public service vehicle designer — are avoided on the track rod, although they are used on the diagonal drag link. The relay levers are clamped on the serrated shaft, the side loading of which is spread over an effective length of 5 in of the bushes, which are of the Oilite or Compo type. A large oil reservoir in the housing reduces to a minimum the frequency of lubrication attention required.

A small but interesting example of the thought that has been given to reduction of cost and weight in details is the bridge-piece that clamps the steering gear trunnion on to its cradle. This is formed from ¼ in plate, with its ends wrapped round to form the bolt eyes, and welded together, where they abut, at the centre of the arch on one side; thus a difficult forging and the attendant machining operations are obviated.

Brakes

Girling hydraulic brakes of an entirely standard pattern are employed. The 10 in diameter drums, with 1¾ in wide shoes, give a total braking area of 133 in^2. The alloy cast iron drums are all interchangeable. They are spigoted on the hub driving flanges and retained by the wheel studs in the usual way, although the usual small countersunk locating screws have been dispensed with. The linings are of Ferodo MS1 material, and they are bonded to the shoes of the brakes.

At the front, the brakes are of the two leading shoe pattern, while at the rear, leading and trailing shoes are used, the mechanical handbrake operation being effected by levers actuated by cables in conduits. The cables pull transversely, the conduit ends being located in brackets on the trailing arms, from which they sweep round and are joined together at a relay lever assembly on the fourth cross-member. The cable ends are connected to short relay levers; a long lever between them, on the same shaft, is connected by a short rod to the handbrake lever, mounted on the third cross-member. A measure of compensation is provided by the connection between the relay levers.

Pendant pedals operate the master cylinders for the brakes and clutch, which are mounted forward of the dash, where they are easily accessible for inspection and topping-up. In the pipe-lines the length of flexible hoses has been reduced to a minimum. At the front the hose is carried between brackets on the chassis frame and the swivel housing, a short rigid pipe completing the run to the brake backplate union. At the rear a short hose on each side connects the pipe on the chassis with a rigid pipe running down the trailing arm, the hose being mounted as near to the suspension pivot point as possible.

Body

Of the pick-up type, with hinged tailboard and flat floor, the body has a load capacity of 23½ ft^3. Boxed wheel arch covers extend the full length of the rear compartment, affording seating for three on each side; the spaces between the covers and the wheel arches form lockers for tools and small gear. The front seat is in one piece and extends for the full width of the body, the squab being shaped to provide three-abreast seating. A folding windscreen and a canvas tilt with tubular frame are part of the equipment.

Sheet steel, En2A, is used throughout for the body construction. All the outer panels are 20 S.W.G. The only shaped parts are the side panels and front wings, which are shallow pressings with a raised motif added more for stiffness than styling. When the panels have been assembled, the whole structure is treated by the Rotodip process, to give complete protection against corrosion.

The main components of the body, including the door sills, scuttle, front wing valances and top panels, sweeping down to the front bumper, form a single structure, spot-welded and fitted with stiffeners, mostly of top-hat section. A bulkhead, behind the seat squab, braces the rear of the body, and the scuttle structure is stiffened by a shallow shelf running below the screen rail, at the centre of which the instrument panel is mounted. The inevitable weakness of the door openings is mitigated by the doors themselves, on which locks of the transverse peg type are used. These enable the doors to function to some extent as part of the structure, besides being extremely cheap and simple. The front wing side panels are bolted to the top panels and scuttle, and are thus easily renewed in case of damage. The radiator is carried between the valances, which are braced by two crossed struts between the radiator and the bolted-on grille panel, which carries the headlamps.

A radiator grille of the simplest possible form is employed. It is an almost flat pressing, and the holes pierced in it are backed by a mesh to prevent large objects from entering and blocking or damaging the radiator. Since all the other panels also are of simple form, they can be easily replaced in the event of accidental damage, and their cost is relatively low. A bench type front seat is employed, and the spare wheel is mounted on the bulkhead immediately behind it. At the rear, the flashing indicators and rear lamps are recessed in the skirt panel to protect them against damage in the event of the vehicle's being backed against a wall or any other obstacle. In short, every consideration has been given to practical requirements.

PROGRESSIVE COLD FORMING

Swiss Machines for Bolt-heading and Nut-forming

ALTHOUGH mainly concentrated in the plants of specialist concerns, the manufacture of bolts and nuts is highly competitive. In the U.S.A. the scale of production, has permitted the development of units which head, reduce, and thread-roll bolts, and their continuous operation on one size of work for relatively long periods. Only in relatively rare instances in Europe will the volume of business in individual sizes be sufficient to justify the installation of such combination machines. More modest batch production tends to foster the use of single purpose, easily set-up machines, although this involves the transfer of the work from one machine to another, and possibly the re-feeding of blanks to bolt-trimming presses and thread-rolling machines. If work is collected and grouped in attempts to ensure favourable machine utilization, some components may be held between operations and suffer ageing. Particularly in the case of parts of high-tensile or alloy steels, this may necessitate an annealing operation if a high rate of tool wear is to be avoided.

Specifically to meet the lower scale of European production, the Swiss firm F. B. Hatebur, of Basle, designed the progressive cold-heading machine shown in Fig. 1. This has one shearing and four subsequent heading stations, and is of the universal type on which, additional to standard or special bolts, other components such as multi-diameter and shouldered shafts and spindles can be mass-produced from coiled stock. It is the intermediate size of the three models manufactured, which together can handle stock from ⅜ in to 1 in diameter and produce bolt blanks up to 28 mm across the flats.

Model BKA-3, illustrated, weighs approximately 29 tons and is driven by a 35 h.p. motor. The maximum diameter of stock that can be worked is ¾ in and the maximum cut-off length is 6 in. The combined heading tonnage is 180. It is capable of high-speed operation and the output ranges from 25,000 to 35,000 pieces per shift of 8 hours. Fig. 2 is a section of a bolt blank produced on the machine, etched to show the grain structure of the material.

Fig. 3 shows the sequence of operations on this machine in the production of a special bolt, using double extrusion and head trimming. When cold heading from stock of a diameter identical with that of the shank, there is no cold working on the shank portion. This results in a considerable difference in tensile strength and elongation as between the head and the shank, and necessitates a final stress-relief annealing operation. In the case of the method shown, however, it will be appreciated that starting from stock of a larger diameter and reducing the whole length of the shank, the tensile strength of the shank is increased. There is thus less tension between this portion and the head and consequently no heat-treating operation is necessary. The bolts coming from the machine require only thread rolling and

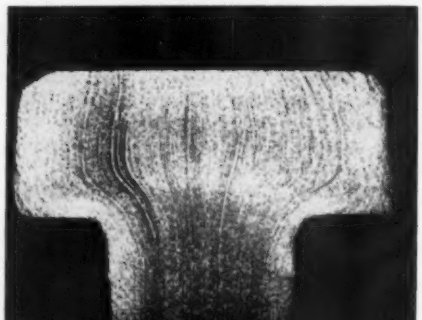


Fig. 2. Etched section of cold-headed bolt blank showing grain structure

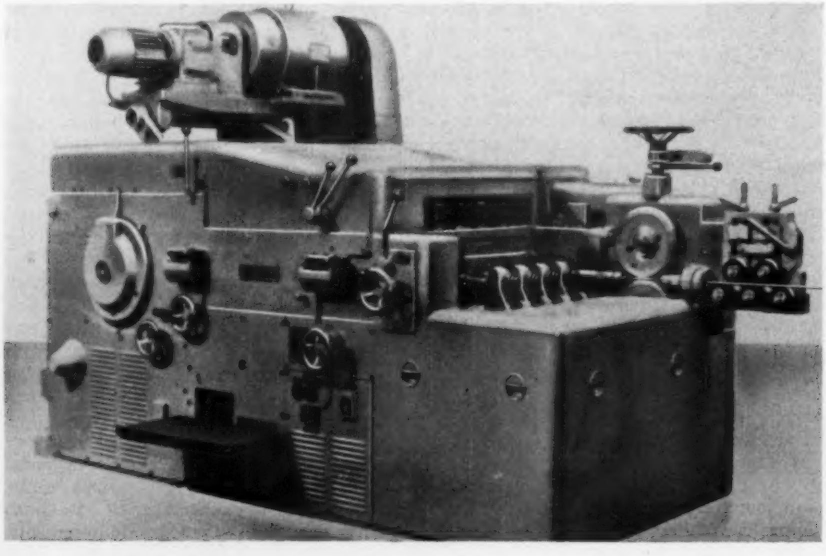


Fig. 1. Hatebur automatic, progressive, cold-heading machine, Type BKA-3

packing before dispatch. The method also has the advantage that various shank lengths can be produced by the same tooling, this being possible due to the fact that the shank reduction for thread rolling is effected as a single operation by the third blow.

The advantage of the trimming operation being carried out on the same machine immediately following heading is an important one. There is no chance of age-hardening of the heads occurring, as was formerly the case when pieces had to be stacked between the header and a separate trimming machine. Furthermore, as the two processes are effected in the same machine, the production keeps in step. While there are some very fast double-blow machines in existence, it is frequently the case in bolt plants that the pace of production is set by the independent trimming machines, which cannot maintain step with the production of the latest type of headers.

The process is claimed to be especially suitable for the manufacture of high-tensile bolts. By reason of the special tensile strength required for this type, however, a heat-treating operation would be necessary.

The tooling layout is shown in Fig. 4. Cam-controlled transfer fingers, with individual timing of opening and closing movements to meet the specific requirements at each heading station, shift the blank positively through the sequence of operations. Each station has its own ejector lever actuated and controlled by an individual cam. The last station is not necessarily reserved for trimming and can be utilized for a forming operation. One bolt blank, ready for thread rolling, is delivered at each revolution of the machine crankshaft.

Cold forming machines for the mass production of nuts from hexagon bar are also manufactured by F. B. Hatebur. Two machines, a preforming press and a finishing press, are used to produce a nut finished to size and ready for tapping. The first machine has two stations. At the first of these, the appropriate volume of material is cut from the stock bar and at the second this blank is squared and formed with a chamfer on one side. Transferred to the second machine, which also has two stations, the blank is automatically fed to the first station where it is shaped to form with a second chamfer and the hole is partially preformed, from both sides, leaving at mid-position a dividing wall of surplus material. Finally, at the second station this wall is punched out as a waste slug and the nut is ejected. Some economy in raw material is secured as the discarded waste amounts to from 7 per cent to 12 per cent only.

Between the two machines the blanks are generally annealed, and always in the case of high-tensile or special alloy nuts. At this stage, also, the blanks may be barrelled or phosphated.

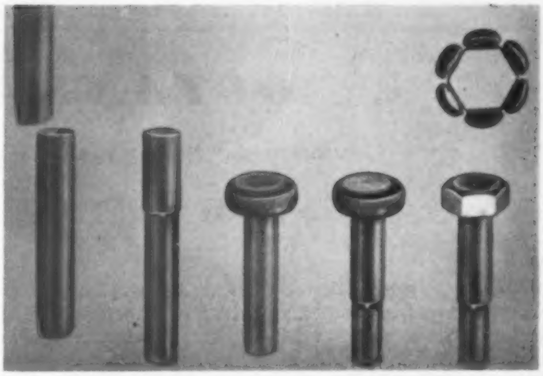
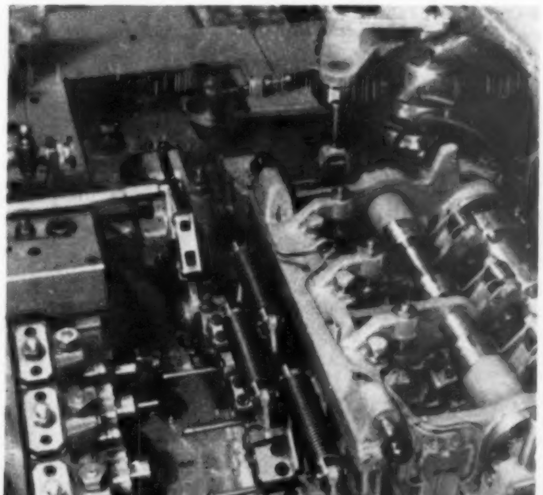


Fig. 3. Sequence of operations in forming a special bolt

Fig. 4. Tooling layout on the BKA-3 Hatebur machine



MACHINE TOOL REBUILDING

WHERE it is planned to operate existing machine tools in conjunction with new tools in a reorganized or re-equipped shop layout, it is essential that all equipment to be retained is in sound condition. If the accuracy of any tool is impaired or its reliability in question, it may constitute a weak link in the chain of productive operations and lower the overall efficiency of the line.

J. Brockhouse and Co., Ltd., Elms Works, Penn Road, Wolverhampton, undertake the complete rebuilding of machine tools of all types, with an unconditional guarantee to meet the manufacturer's original specification. Machines are completely stripped, cleaned, inspected, and reports are prepared, copies of which are forwarded to the owner. Generous replacement of worn parts is carried out.

Hydraulic equipment is examined, tested and where necessary, components and piping are replaced. Electric equipment is tested, rewired or replaced as required. All connections between electrical units are rewired with P.V.C. cable. Machines are tested under power through their designed range and then submitted to final inspection. All machine alignments are restored to the manufacturer's limits. Before dispatch the machines are filled and painted to the owner's standard colour.

In many instances it is possible to bring a machine of old design up to the standards essential for modern production, and general-purpose machines can be converted to specials. The firm also undertakes the building of special machines and production equipment to meet specific requirements.

OCTANE NUMBERS

Laboratory and Road Rating Methods and Their Practical Significance

K. Arter, B.Sc. (ENG), M.I.Mech.E.*

IN the early 1920's, Ricardo established in his pioneer work that the detonating tendency of the fuel is the outstanding factor determining its value for use in an engine. He expressed the anti-knock quality of fuels in terms of the highest useful compression ratio, generally abbreviated to HCR, using his E.35 variable-compression engine. A disadvantage of this method of expressing the anti-knock quality is that the results are not directly applicable with other, perhaps less efficient, designs of combustion chamber.

Meanwhile, Midgley and Boyd in the United States of America discovered the remarkable properties of tetra-ethyl lead, with regard to the suppression of detonation, and were developing their bouncing pin apparatus for measuring detonation intensity. In 1929, the American Co-operative Fuel Research, or C.F.R., Committee standardized an improved form of the bouncing pin for the variable-compression C.F.R. knock testing engine, which became an international standard. After being used more or less in its original form for over twenty years, the bouncing pin has now been superseded by electronic instrumentation of greater sensitivity and reliability.

To provide a common basis for co-operative work between laboratories, the C.F.R. Committee adopted two standard hydrocarbon reference fuels, iso-octane, which is 2 : 2 : 4 trimethyl-pentane, and normal heptane. Octane number, or O.N., of a motor fuel was defined as the percentage by volume of iso-octane in a mixture of iso-octane and normal heptane that matches the knock characteristics of the fuel being tested. The standard laboratory test is made in the A.S.T.M.-C.F.R., single-cylinder, variable-compression engine under closely controlled conditions of speed, temperature, mixture strength and spark timing. To determine the knock rating, the compression ratio is adjusted to maintain a constant knock intensity, as indicated by the knock meter.

At the time they were chosen, it was thought that these two standard hydrocarbons embraced the entire range of anti-knock quality that would be encountered in refining practice. However, during the last twenty years, new processes have been developed for the large-scale manufacture of fuels that far surpass iso-octane in anti-knock quality. These remarkable developments introduced new problems of defining and measuring the anti-knock value of fuels. Since the octane number scale is not based on any sort of fundamental physical measurement, it can only be extrapolated beyond the 100 O.N. point on some arbitrary basis, for example, by adding tetra-ethyl lead to the iso-octane. For the same reason, octane numbers determined in a production car engine are not necessarily equal to values found in the laboratory engine. It has, therefore, proved necessary to standardize several different methods of test. All these tests involve the use of the C.F.R. engine, but with differences in speed, temperature and charge density.

Laboratory engine test methods

There are two standard knock-rating tests for motor fuels. They are designated the Research, or A.S.T.M. D908-55 method, and the Motor, or D357-53 method. There is also a method of a similar kind for testing aviation fuels under supercharged conditions of operation. The standard conditions of operation for the Research and Motor methods are summarized in Table I. All knock ratings, regardless of octane number, are made at about the same intensity or degree of knock, and there is a carefully specified procedure for obtaining the standard knock intensity, or K.I. With each fuel, the fuel : air ratio is adjusted by hand to give the maximum K.I.

By definition, the performance of a motor fuel of 100 O.N., when tested by the Research method, is equal to that of iso-octane. However, its O.N. indicated by the Motor method of test will usually be lower, because of the influence of the higher temperature and speed used in this test. The difference can vary from two to three numbers, with some types of fuel, up to ten or twelve with others. Fuels that show a large difference between the two ratings are often described as temperature sensitive, their degree of sensitivity being defined as follows:

Sensitivity = Research O.N. — Motor O.N.

Extension of the scale

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* Esso Research Ltd., Abingdon, Berkshire.

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90	90	—	—	—	—
95	95	—	—	—	—
100	100	—	—	—	100
101	—	0·07	0·08	0·02	103
102	—	0·16	0·19	0·04	106
103	—	0·25	0·30	0·07	109
104	—	0·35	0·42	0·09	112
106	—	0·60	0·72	0·16	118
108	—	0·90	1·08	0·24	124
110	—	1·28	1·54	0·34	130

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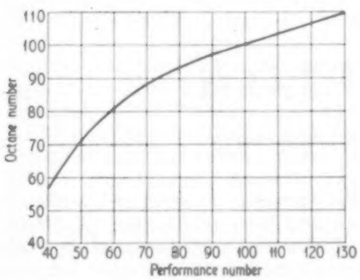

The relationship between octane number and performance number

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$$\text{O.N. above } 100 = 100 + \frac{\text{P.N.} - 100}{3}$$

These high octane numbers are frequently referred to as C.R.C. octane numbers, because the formula is one recommended by the Co-ordinating Research Council, in New York. Engine evaluations are made by comparing the test fuel with leaded iso-octane: Table II shows values up to 110 C.R.C. octane number. While the same numerical relationship would apply for both Research and Motor O.N., motor fuel ratings over 100 are normally understood to be based on the Research method.

Since the relationship between performance number and octane number is not a straight line, octane number increments have increasing value, in terms of engine performance, as the 100 O.N. level is approached. This is also true above 100, as is shown by the data in Table III, which was obtained with a Ricardo E.6 research engine.

An increase from 94 to 96 O.N. gives a gain of 1·1 lb/in^2 in knock-limited i.m.e.p., while an equal increment from 102 to 104 O.N. yields 2·5 lb/in^2 gain. It is already recognized that the efficiency with which fuels of high O.N. ratings can be used depends on the cylinder head design, but there is considerable evidence from the United States of America that the employment of compression ratios up to at least 10 : 1 may be justified by the resultant savings in fuel consumption.

Road test methods

While the C.F.R. laboratory engine is essential for research and for the control of product quality, clearly the important practical factor is the performance of the fuel in the car on the road. The most commonly used road test method is the Uniontown procedure, so named because it was first used in co-operative tests in 1932 in Uniontown, N.J. With this method, the car is accelerated at full throttle from a uniform low speed, say 10 or 15 m.p.h., and the detonation intensity is

C.F.R. knock-rating engine and electronic detonation meter

OCTANE NUMBERS

Laboratory and Road Rating Methods and Their Practical Significance

K. Arter, B.Sc. (ENG), M.I.Mech.E.*

In the early 1920's, Ricardo established in his pioneer work that the detonating tendency of the fuel is the outstanding factor determining its value for use in an engine. He expressed the anti-knock quality of fuels in terms of the highest useful compression ratio, generally abbreviated to HCR, using his E.35 variable-compression engine. A disadvantage of this method of expressing the anti-knock quality is that the results are not directly applicable with other, perhaps less efficient, designs of combustion chamber.

Meanwhile, Midgley and Boyd in the United States of America discovered the remarkable properties of tetra-ethyl lead, with regard to the suppression of detonation, and were developing their bouncing pin apparatus for measuring detonation intensity. In 1929, the American Co-operative Fuel Research, or C.F.R., Committee standardized an improved form of the bouncing pin for the variable-compression C.F.R. knock testing engine, which became an international standard. After being used more or less in its original form for over twenty years, the bouncing pin has now been superseded by electronic instrumentation of greater sensitivity and reliability.

To provide a common basis for co-operative work between laboratories, the C.F.R. Committee adopted two standard hydrocarbon reference fuels, iso-octane, which is 2 : 2 : 4 trimethyl-pentane, and normal heptane. Octane number, or O.N., of a motor fuel was defined as the percentage by volume of iso-octane in a mixture of iso-octane and normal heptane that matches the knock characteristics of the fuel being tested. The standard laboratory test is made in the A.S.T.M.-C.F.R., single-cylinder, variable-compression engine under closely controlled conditions of speed, temperature, mixture strength and spark timing. To determine the knock rating, the compression ratio is adjusted to maintain a constant knock intensity, as indicated by the knock meter.

At the time they were chosen, it was thought that these two standard hydrocarbons embraced the entire range of anti-knock quality that would be encountered in refining practice. However, during the last twenty years, new processes have been developed for the large-scale manufacture of fuels that far surpass iso-octane in anti-knock quality. These remarkable developments introduced new problems of defining and measuring the anti-knock value of fuels. Since the octane number scale is not based on any sort of fundamental physical measurement, it can only be extrapolated beyond the 100 O.N. point on some arbitrary basis, for example, by adding tetra-ethyl lead to the iso-octane. For the same reason, octane numbers determined in a production car engine are not necessarily equal to values found in the laboratory engine. It has, therefore, proved necessary to standardize several different methods of test. All these tests involve the use of the C.F.R. engine, but with differences in speed, temperature and charge density.

Laboratory engine test methods

There are two standard knock-rating tests for motor fuels. They are designated the Research, or A.S.T.M. D908-55 method, and the Motor, or D357-53 method. There is also a method of a similar kind for testing aviation fuels under supercharged conditions of operation. The standard conditions of operation for the Research and Motor methods are summarized in Table I. All knock ratings, regardless of octane number, are made at about the same intensity or degree of knock, and there is a carefully specified procedure for obtaining the standard knock intensity, or K.I. With each fuel, the fuel : air ratio is adjusted by hand to give the maximum K.I.

By definition, the performance of a motor fuel of 100 O.N., when tested by the Research method, is equal to that of iso-octane. However, its O.N. indicated by the Motor method of test will usually be lower, because of the influence of the higher temperature and speed used in this test. The difference can vary from two to three numbers, with some types of fuel, up to ten or twelve with others. Fuels that show a large difference between the two ratings are often described as temperature sensitive, their degree of sensitivity being defined as follows:

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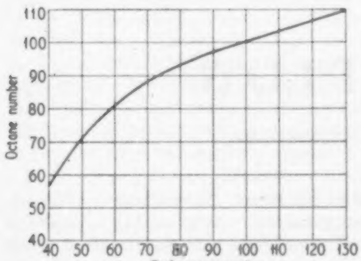

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noted. Then the test run is repeated successively, with iso-octane/heptane blends, which differ by two or three numbers, until a pair of blends is found such that with one the audible knock is slightly less than with the test fuel, and with the other it is slightly more. Differences in the car speed at which maximum knock is heard are ignored. The octane rating of the test fuel is then estimated by interpolation. Ratings above 100 O.N. are made in a similar way, using leaded iso-octane.

An alternative but rather more laborious test is that termed the Modified Borderline method. For this test, the car is fitted with instruments that give a continuous indication of road or engine speed and of ignition timing, a manual control being used to vary the spark advance. The test runs are made in top gear at full throttle over the desired speed range on a level road. During these runs, the manual control is adjusted to maintain the knock at trace level. Curves are plotted to relate speed with the spark timing that gives trace knock with the test fuel and with the reference fuels. From these curves, the octane number of the test fuel at any speed of operation can readily be determined. This technique eliminates the effects of transient mixture distribution phenomena in the induction manifold, which can have an important influence on Uniontown ratings of some types of motor fuel.

Road ratings of commercially marketed fuels nearly always fall somewhere between their Motor and Research ratings, as determined in the laboratory, although the rating of certain temperature-sensitive fuels in some cars may be a little above that obtained by the Research method. Generally speaking, side-valve engines with cool manifolds, which nowadays comprise the large majority, give ratings close to Research octane number. Therefore, it is now customary, when specifying or marketing a fuel, to quote the Research octane number, whereas before 194[illegible] the Motor octane number was generally used.

TABLE III

C.R.C. octane number	Knock-limited i.m.e.p. lb/in²	kg/cm²
94	161·6	11·36
96	162·7	11·44
98	164·1	11·54
100	165·9	11·66
102	167·7	11·79
104	170·2	11·97

During recent years, Esso research workers have tested many hundreds of cars throughout Europe, using mainly the Uniontown procedure. The information so obtained is invaluable in deciding the quality levels appropriate to different marketing areas. Given both Research and Motor octane numbers of a particular fuel, its road rating in different makes of cars can now be predicted with considerable confidence.

It seems appropriate to end an article of this kind by pointing to a current misconception. Aviation fuel, of 100/130 grade, now being used in many car races, does not have an octane number of 130. The correct interpretation of this grading is that its performance number is 130 under rich mixture take-off conditions in a supercharged engine, and that its Motor octane number is approximately 100. Because of its hydrocarbon composition and high tetra-ethyl lead content — both dictated by aviation requirements — its Research octane number is not much in excess of 100. For these reasons alone, such a fuel is not typical of 100 Research O.N. motor fuels that are currently marketed in Europe.

AXLE LUBRICATION

Castor Oil for Bus Rear Axles Improves Fuel Consumption

LONDON Transport have started a large-scale test, of an improved method of lubricating the rear axles of their buses, which it is hoped will ultimately save them £120,000 a year in fuel costs. The test involves a fifth of London's buses; this is expected to give an immediate saving of £20,000 a year. These vehicles will now be operated with castor oil for the lubrication of their rear axles, in place of the normal mineral oil generally used for buses and other road vehicles.

It is stated that tests by London Transport Research Department, involving highly accurate measurements carried out on small numbers of buses over the last three years, have shown that castor oil gives buses an improved fuel consumption of 2 to 3 per cent, in terms of miles per gallon. This is attributed to the greater oiliness, or lubricity, of castor oil, which reduces friction losses in the rear axle units. Running is unaffected in other respects.

Castor oil has been used, of course, to some extent for many years as a motor vehicle lubricant, for instance in racing cars and even in buses, but latterly it has been largely replaced by mineral oil, because of its higher cost and a tendency to gumming. It has also been used at times for rear axle lubrication, but the fuel saving potentialities were not generally appreciated until careful and accurate measurements were made, and allowances made for traffic and stopping variations, temperature and other factors. Because of the small quantity of lubricant used in rear axles, the higher cost of castor oil will be insignificant in comparison with the gain in fuel consumption, while the tendency to gumming is overcome by using an oxidation inhibitor.

The gain will be supplementary to a further £350,000 a year, which London Transport has already made through previous bus lubrication research. This research led to a change-over to much thinner oil than that generally regarded previously as standard for engine lubrication for buses. In this way, a fuel saving of 6 per cent in London's buses has been obtained. The use of the thinner lubricant has since become general among bus operators.

Before reaching the present stage with rear axle lubrication, London Transport experimented with several lubricants of different viscosities to see if thinner oils would produce a saving in fuel, as they had done in the case of the engine lubricants. Various grades of oil down to S.A.E. 5 were used, instead of the normal S.A.E. 140 rear axle type, but it was found that within this range there was no detectable effect on fuel consumption.

Tests were made with certain proprietory blends of castor oil and a wholly synthetic oil. An improvement of 2 to 3 per cent was noted in the fuel consumption obtained with these blends; a similar improvement was obtained when castor oil and a synthetic oil were each tested separately. It was concluded, therefore, that the benefit was due to the improved lubricity of these oils, which resulted in a reduction in friction losses. While the current large-scale test on 1,358 buses is being made with castor oil, tests are also being made at one garage with a synthetic oil, the long-term performance of which has still to be accurately determined.

LOCKHEED POWER BRAKE

Accumulator Actuated Hydraulic Servo System Designed for Public Service Vehicles

IN recent years, considerable attention has been devoted to the improvement of braking systems, particularly for commercial vehicles. There have been two main aims, so far as control is concerned. One is at the reduction of effort required to actuate the controls and the other is at sensitivity of control. Servo braking has, of course, been adopted for many years with a view to reducing the effort required by the driver. However, when the pressure required for brake operation has to be transmitted through long lengths of pipeline, there inevitably is some delay, particularly when air or vacuum brakes are employed. There can be a certain amount of lost time, even when hydraulic actuation is used, if the hydraulic pressure has to be built up from zero, by application of the driver's foot to the pedal. An obvious remedy is to employ a power-actuated system in which the hydraulic fluid is under pressure all the time and can be brought into operation simply by opening the valve. This type of system has the additional advantage that pedal travel is reduced to an absolute minimum and there is virtually no lost motion.

The Lockheed system

Automotive Products Co. Ltd., of Leamington Spa, have produced a power braking system, in which the hydraulic fluid is maintained continuously under pressure by means of an engine-driven pump, operating in conjunction with accumulators. The layout of this system is shown in Fig. 1. A large filter is fitted in the supply tank. Oil is drawn through this filter to the engine-driven pump, whence it is delivered to the cut-out valve mounted on the end of number 1 accumulator, which is the upper of the two in the diagram. A branch from the delivery pipe is connected to the non-return valve on the end of number 2 accumulator.

Each accumulator is connected to a separate section of the tandem power-valve. The section connected to number 1 accumulator serves the rear brakes and that connected to number 2 the front brakes. There is a return line, which takes the fluid from the cut-out valve, through the front brake valve in the tandem power valve, to the tank. It is arranged in this way so that a continuous-flow supply is always available to the front brakes.

When the brake pedal is depressed, it actuates the tandem power-valve and thus closes the return to the tank and admits pressure from the pump and accumulators to the brakes. Release of the brake pedal cuts off the pressure supply, opens the return to the tank, and allows the fluid to escape from the brake lines. This operation will be described in more detail later.

Initially, when both the accumulators are in the discharged condition the position of the cut-out valve is such that the outlet to the continuous-flow line is closed. When the engine is started, fluid flows from the pump into number 1 accumulator. As the pressure in this accumulator rises, so also does the pressure in the delivery line from the pump: this causes the non-return valve to open on number 2 accumulator, which also begins to charge. When the pressure has built up in both accumulators, the cut-out snaps over, releasing fluid from the supply to the continuous-flow line, and then through the front brake valve to the return line to the tank.

Since a considerable proportion of the fluid supply to the front brakes is furnished directly by the pump, number 2 accumulator discharges less rapidly than number 1. When the pressure in number 1 drops to the pre-set low limit, the cut-out snaps over again, and both accumulators begin to charge. An outstanding feature of the system is the dual lines, which ensure that, in the unlikely event of a pipe or unit failure in any line, the brakes to at least one axle will still be operative. Additionally, a visible indication is given immediately to the driver to warn him of impending trouble.

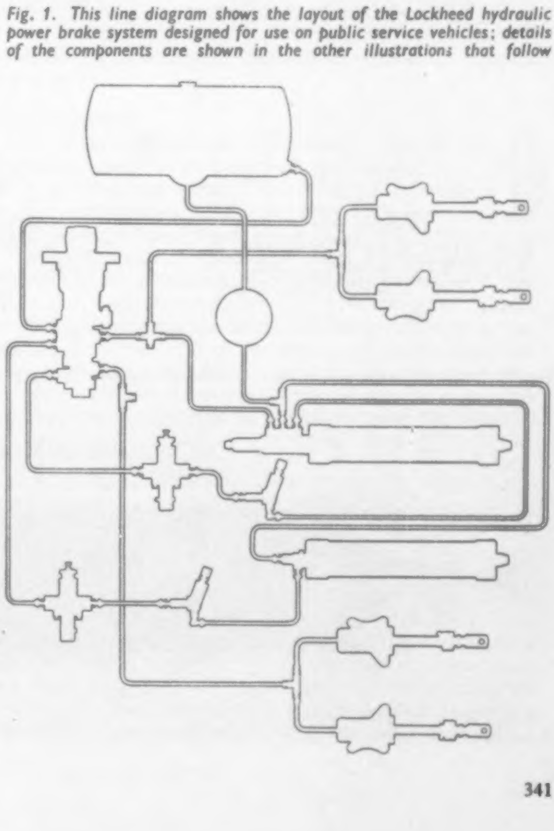
Should leakage occur at the supply tank, low and high pressure lines, delivery lines to the accumulators, or should the pump fail, the accumulators would not be recharged. As the pressure falls owing to repeated applications of the brakes, one of the warning switches operates and a signal arm drops to indicate to the driver a loss of pressure. There is one warning switch in the delivery line from each accumulator to the tandem brake valve.

THE COMPONENTS

Supply tank

A cylindrical tank is employed, Fig. 2. When filled to the correct level, with the accumulators in the discharged condition, it has a capacity of 3 gal of fluid. The filler orifice is arranged in such a manner that, even if the tank is carelessly over-filled, with the accumulators in the charged condition, there is still room for the surplus fluid to return from the accumulators without causing the tank to overflow.

Fig. 1. This line diagram shows the layout of the Lockheed hydraulic power brake system designed for use on public service vehicles; details of the components are shown in the other illustrations that follow



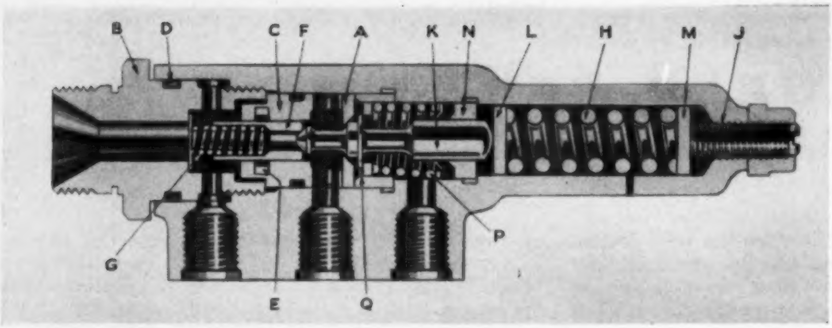


Fig. 3. Left: In the cut-out valve there are two seats; these are marked A and F in this illustration. The valve seat A is fixed, while F slides axially and is loaded by the spring G

Fig. 2. Below: The filler orifice on the tank is arranged in such a manner that even if the system is carelessly over-filled, with the accumulators in the charged condition, there is still room for the surplus fluid to return from the system to the tank

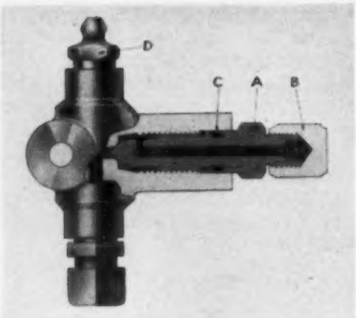
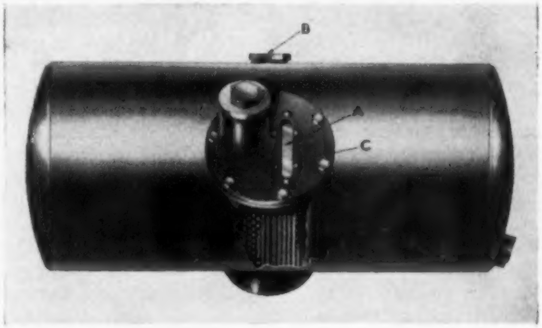


Fig. 6. Left: One of the four check-gauges, which are used both for bleeding the system and as an adaptor for the attachment of a pressure gauge for checking it

Fig. 4. Below: These six diagrams show the principle of operation of the cut-out valve illustrated in more detail in Fig. 3



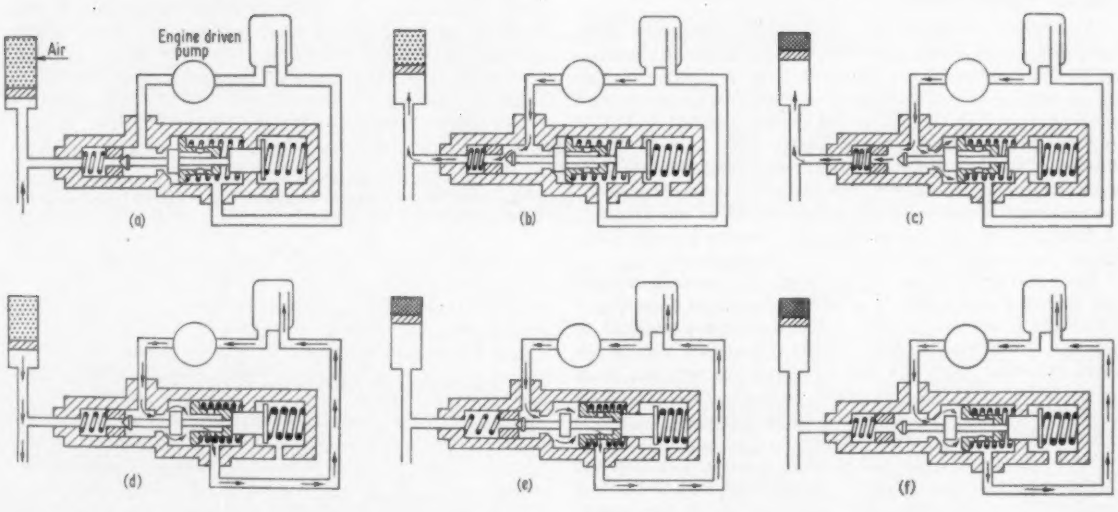
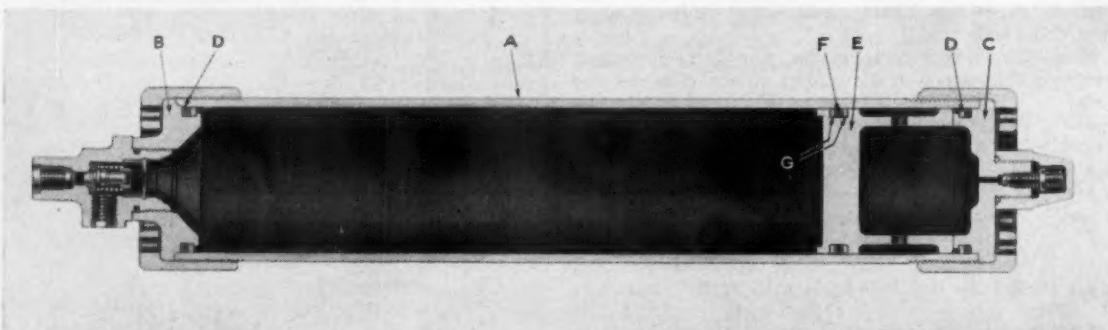


Fig. 5. Below: In each accumulator, a floating separator E, fitted with the sealing rings F backed by the seals G, divides the two sections



The filler has a screwed-down cap with a copper sealing washer. A visual gauge, A, is incorporated in the cover plate on which the filler is mounted; thus, the fluid level can be checked without removing the cap. An air vent B, shielded by an anti-splash baffle, is fitted at the highest point of the tank.

A PurOlator Micronic paper element filter, which has an effective area of 827 in^2, is fitted over the outlet to the pump. This filter is capable of trapping all foreign matter larger than 20-25 microns. It is housed in a cylindrical chamber connected to the main part of the supply tank in such a way that air cannot be sucked by the pump into the system. The filter element can be renewed as required, simply by removing the cover plate C.

Cut-out valve

In Fig. 3 is illustrated the cut-out valve. It comprises a body casting, in which a valve seat A is retained by a screwed-in adaptor B and a sleeve C. Leakage is prevented by a seal D in a groove round the adaptor. Assembled into the sleeve is the seal E and the sliding valve seat F, which is loaded by the spring G. The other end of the body casting houses the spring H, and its two end washers, L and M. A screw adjuster J regulates the compressive load in the spring. This load is applied to the valve spindle K. On the valve spindle there are two conical facings, one to seat on A and the other to seat on F. A seal N, through which the spindle K passes, prevents leakage of fluid into the spring housing, which is vented to atmosphere. Another spring P acting on a flutter plate Q, also loads the valve spindle.

In Fig. 4, the valve is shown in the static condition at (a), that is, with the engine pump not in operation and the accumulator discharged. The springs P and H keep the valve seated at A, while the spring G holds the sliding valve seat F against the conical valve face. In (b) is shown the position of the valve when the engine-driven pump starts to operate. In these circumstances, the fluid lifts the sliding valve seat F and flows into the accumulator, compressing the air and thus storing energy. The springs P and H retain the valve on its seat A until the pressure in the accumulator reaches the cut-out value. Then, the pressure acting on the valve lifts it slightly, as shown in (c). This allows the pressure to act on the flutter plate Q, which it displaces along the valve spindle against the action of the spring P, as shown at (d).

Fluid then escapes through holes in the flutter plate, to the reservoir and, in consequence, the delivery pressure of the pump falls. This allows the accumulator pressure to push the sliding seat F on to the valve, as shown in (e). Further movement of the sliding seat pushes the stem and fully opens the valve A, against the action of the spring H. The whole of the delivery of the pump then flows through the flutter plate to the reservoir. This is the cut-out condition.

As the pressure in the accumulator falls, during operation of the brakes, the spring H pushes the valve towards its seat A. When the cut-in pressure is reached, the valve actually seats and the spring P returns the flutter plate on to the valve. This enables the charging cycle to begin again, as shown in (b).

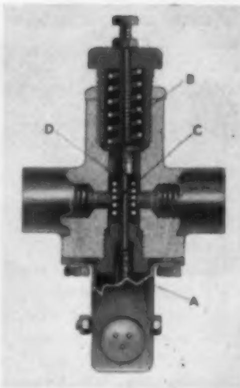
Accumulators

In construction, the two accumulators are identical, but, as can be seen from Fig 1, they have different end fittings. The number 2 accumulator is illustrated in Fig. 5. This is fitted, at one end, with the non-return valve, which allows it to be charged by the pump pressure, but isolates its pressure outlet line, in case of failure of the remainder of the system.

The accumulator consists of a cylinder A, to which a fluid head B and an air head C are secured by means of screw caps. Leakage between the heads and the ends of the cylinder is prevented by the seals D. The heads are both drilled and tapped axially, one for the air inflation valve and the other, the fluid head, to receive the cut-out or non-return valve, according to whether it is used in the number 1 or number 2 position. Inside the cylinder there is a floating separator E, fitted with sealing rings F, backed by seals G. These seals isolate the fluid from the air.

For the initial setting, the fluid is completely discharged from the accumulator, and air is pumped in through the inflator valve in the head, until the pressure reaches 500 lb/in^2. The separator, of course, is forced along the cylinder by the air pressure, until it is arrested by the fluid head. When the hydraulic pump begins to operate, fluid is directed by the cut-out valve into the accumulator. As the pressure increases, the separator moves towards the air head, compressing the air and maintaining a balance between the air and fluid pressures. Thus it provides storage space for fluid under pressure. As has been mentioned before, when the cut-out valve closes the inlet to the accumulator, the fluid from the pump is diverted to the continuous-flow part of the circuit. The fluid capacity of the accumulators is adequate for several brake applications when the engine is not running.

Fig. 7. One of the two warning switches that are fitted in the accumulator circuits. The two switches are installed in series, so that a failure of either circuit sets the signal at danger and extinguishes the pilot lamp



Check-gauges

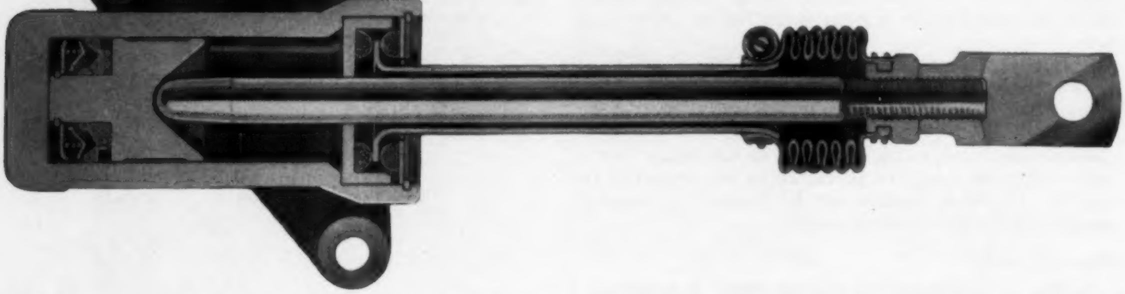
One of these components is illustrated in Fig. 6. Four are employed, one in each brake and accumulator line. They serve the dual purpose of facilitating the bleeding of the system and providing for the attachment of a pressure gauge for checking the performance.

A bleeder screw D, of normal design, is employed. The pressure gauge attachment comprises a screw plug A, the outer end of which is threaded to receive the gauge. Under normal operating conditions this thread is protected by the cap B. The inner end of the plug is of conical form and seats in the body in a manner similar to the bleeder screw. To prevent the escape of fluid when the valve is opened for test purposes, a seal C is fitted in a groove round the plug.

Warning switch

One of the two warning switches that are fitted in the accumulator circuits is illustrated in Fig. 7. It comprises a switch A, the contacts of which are closed by the spring B when the pressure in the outlet line from the accumulator falls below a certain value. In these circumstances, a pilot lamp is illuminated and a warning arm raised. When the line is pressurized, the fluid in the chamber C forces the plunger D upwards and closes another circuit. This energizes the solenoid, which lowers the signal arm. At the same time, the signal lamp is switched off. Since the two switches are in series, failure of either circuit sets the signal at danger and extinguishes the pilot lamp. It follows that there is no

Fig. 10. An adjustable fork joint is fitted on the end of the operating cylinder, but the main adjustment is effected at the brake levers



possibility of an electrical fault masking a defect in the brake system. The care that has been devoted to ensure that failures are unlikely to occur is one of the noteworthy features of the Lockheed system. Another commendable feature is the way in which failures, if they do occur, are indicated clearly to the driver of the vehicle.

Tandem power-valve

In the design of the tandem power-valve, the following factors have been carefully considered. First, the greatest possible attention has been devoted to safety. It is for this reason that the valve is in tandem form and controls two separate brake lines, in which it maintains equal pressures. In the event of a failure such as a broken pipe in one line, the valve controlling the other line is operated directly by mechanical means and is unaffected in any way. The principles applied in this instance are similar to those used in the design of the well known Lockheed tandem master cylinder.

An illustration of the tandem power valve is shown in Fig. 8. In this unit, provision is made to cater even for the breakage of a control spring. Should this eventuality arise, a small extra travel of the pedal brings the stops AA into contact, so that the valve is immediately operated directly.

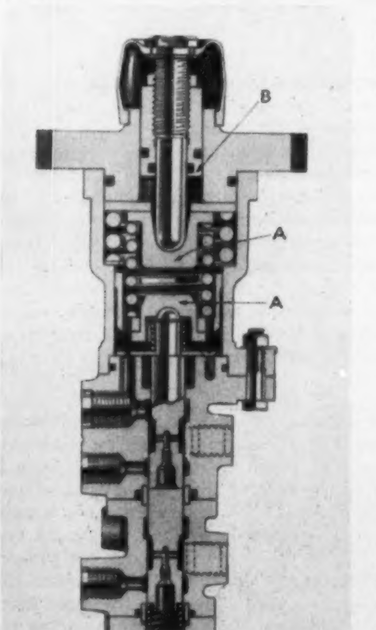


Fig. 8. Left: The tandem valve controls two separate brake lines and maintains equal pressures in both

The second important consideration in the design of the unit is that of reliability and freedom from maintenance attention during service. To satisfy these requirements, the policy of the manufacturers has been to eliminate all rubber seals operating under pressure. Instead, metal piston valves are used, and they are ground and lapped to give a very long life without any attention whatever. The only rubber seals employed are those used between components that do not have relative movement, and a rubber gaiter is employed to enclose the end of the push rod sleeve. These rubber seals are only subjected to the return line pressure.

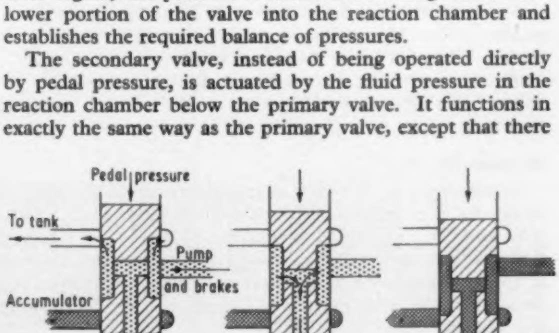
A diagrammatic illustration, Fig. 9, shows in the simplest possible manner the basic principle of operation of a single, as opposed to tandem, valve. There are three connections to the valve, one is the return to the supply tank, the second is the connection from the brake line into which the overflow from the cut-out valve is fed, and the third is a line connected to the accumulator.

When the brakes are not in operation, the valve is in the upper position, as shown at (a); in this condition, the fluid from the brake line is free to flow past the upper valve port into the return to the tank. When pressure is applied to the brake pedal, the valve is pushed down and closes off the outlet of the fluid to the tank, as at (b). Then, the flow from the pump passes through the lower drilled portion of the valve, to pressurize the reaction chamber below. In this way, a balance is maintained, between the pedal pressure and the reaction of the valve, so the pressure in the system is maintained at a value proportional to the pedal pressure applied by the driver.

In the condition shown at (c), the engine is not running and therefore the pressure in the chamber below the valve cannot be built up by fluid flowing from the brake line. Under these conditions, the piston valve moves further down and opens the connection from the accumulator to the brake line. Again, this pressure is transmitted through the drilled lower portion of the valve into the reaction chamber and establishes the required balance of pressures.

The secondary valve, instead of being operated directly by pedal pressure, is actuated by the fluid pressure in the reaction chamber below the primary valve. It functions in exactly the same way as the primary valve, except that there

Fig. 9. Right: Diagrammatic illustration showing in the simplest possible manner the basic principle of operation of a single, as opposed to a tandem, valve



is no continuous-flow circuit, and pressure on top of the valve, therefore, immediately opens the accumulator port and allows fluid to flow to the brake line until the appropriate degree of balance is reached. If the primary line should fail, the primary valve descends to make metallic contact with the secondary valve, which is opened in the normal way. The occurrence of a defect in the secondary valve line would not affect the operation of the primary valve. In the valve stems, the holes leading to the reaction chambers are locally restricted. This is to ensure smooth response to pedal pressure, and eliminates the possibility of surge effects.

The pedal ratio and reaction areas have been calculated to give light but progressive operation, in accordance with modern standards, and the chamber containing the springs has been designed so that the valve can be set to give a predetermined degree of deceleration. When the pedal is depressed, the push rod moves down the bore, compressing the inner spring and applying pressure progressively to the brake cylinders. After the push rod has reached the stop, B, any additional pressure is resisted by the outer spring, which is set to a predetermined load. When sufficient load is exerted by the driver to overcome the compression in this spring, additional pressure is supplied to the brakes. This device allows for a maximum deceleration to be obtained when required, but ensures that normal braking will not be too sudden for passenger discomfort.

Brake operating cylinders

All four operating cylinders, one of which is illustrated in Fig. 10, are similar, but handed. They have been specially designed to fit into a limited space on a particular application.

The body is of cast iron. It contains a brass piston fitted with a synthetic seal having a reinforced fabric heel. This combination has been found to give great durability. The seal is held against the cylinder wall by an expander. A steel tube, sealed at one end by a gaiter, encloses the long push rod. The other end of the tube is attached to the cylinder by a flexible rubber mounting, the arrangement of which can be seen clearly in the illustration. On the push rod there is a fork joint, or clevis, which is adjustable for the initial setting. However, during service, the main adjustment for the brakes is effected at the brake levers.

THREE NEW B.R.S. VEHICLES

Standard Units Modified Extensively to Suit Special Operational Requirements

IN larger depots, it is frequently necessary to move loaded and unloaded semi-trailers to and from loading banks and parking places. If this is done with normal prime mover vehicles, the coupling and uncoupling operations, involving retraction and extension of the semi-trailer landing gear, are not only slow, but also reduce the availability of prime movers for road operation. Consequently, British Road Services have developed a one-man-operated slave motive-unit, capable of handling semi-trailers loaded to maximum capacity. This enables the trailer to be moved about the depot without its landing gear retracted. To accomplish this, the motive-unit has a hydraulically operated fifth wheel coupling, by means of which the front end of the semi-trailer can be lifted until its landing gear is clear of the ground.

The slave motive-unit currently in use is based on the Douglas Tugmaster and it has been produced by Douglas Equipment Ltd., of Cheltenham. Its SAE/SMMT fifth wheel coupling is fitted with a hydraulically actuated levelling device, which, within the required limits, automatically adjusts the height of the coupling to give smooth and positive engagement with the rubbing plate of the semi-trailer. Two eight ton hydraulic rams are used to adjust the height of the fifth wheel.

During the coupling operation, the slave prime mover is reversed to the semi-trailer and the position of its fifth wheel is regulated by the hydraulic control until it is slightly higher than the rubbing plate of the trailer. When the prime mover is reversed further, the leading edge of the rubbing plate depresses the two strips on the fifth wheel. This depression of the strips releases the hydraulic pressure so that the fifth wheel can slide easily into position beneath the semi-trailer. Finally, the fifth wheel is raised to lift the landing wheels clear of the ground.

To keep the tractors fully employed in the depots, other equipment may be added, such as fork lift attachments and drawbar gear. The drawbar gear can be used to operate trailer type floor sweepers, four-wheel trailers or to move other vehicles. Another project in view is the modification of one of the prototypes so that the driver is seated sideways; he will then have a better view to the rear, for coupling-up.

In addition, British Road Services have recently introduced a modified three-ton parcels van designed for improved access, from both sides, to the driver's seat. The vehicle is an Austin, forward-control vehicle, with a combined body and cab of B.R.S. design. All the pedal controls have been moved 11 in to the rear and the steering column rake has been increased. These alterations enable the driver to reach his seat without having to climb over either front wheel arch. An extra-large windscreen is employed to improve the range of vision, particularly down towards the ground. Forward of the front bulkhead, the engine cowl consists of a glass-reinforced polyester moulding, which, on removal, gives complete and easy access to the engine for maintenance and adjustment.

A standard Leyland Octopus, which is a 24 ton gross vehicle weight, eight-wheel vehicle has been fitted with a prototype 24 ft platform body, which can be readily removed in three 8 ft sections by a fork lift truck. This arrangement, termed the Tripad system, has been devised and made by British Road Services to handle more economically certain types of traffic. The three sections can be readily transferred to rail vehicles, and loading or unloading can be effected in a matter of minutes, since the sections can be handled without immobilizing the carrying vehicle. Another useful feature of the arrangement is that individual sections can be removed from or mounted on the vehicle at intermediate points along the route. This system can be applied to a variety of vehicle types, including semi-trailers.

The design is such that the 8 ft sections are automatically aligned when they are remounted. This alignment is effected by means of male and female pyramids used in conjunction with a quick-acting locking device actuated by a detachable crank handle. Each section can be fitted with detachable headboards and sides, and can also be assembled as a container. The unladen weight of the prototype vehicle, complete with its body sections, does not exceed 9 ton. Thus, the legal payload per section is 5 ton. At present, the tare weight of each section is 8 cwt, but it is expected that later versions will be slightly lighter. Each of these three vehicles is an experimental prototype, subject to further development.

The additions to the Mound Road plant are a 60 × 520 ft bay, the full length of the south end, and a large department at the north-east corner

V-8 Engine Manufacture

Advanced Production Methods Used in the Manufacture of the Chrysler Plymouth Engine

IN the United States and, to a lesser extent, in Great Britain, ever increasing wage rates and long production runs have provided an incentive and made possible many improvements in the handling and machining of automobile parts. Probably the most advanced example of the technique of mechanical handling and automatic manufacture is to be found in the Chrysler Corporation's Mound Road engine factory, situated on the outskirts of Detroit, where are manufactured the engines for the Corporation's Plymouth series of automobiles.

With the Chevrolet and the Ford, the Plymouth car is, of course, one of the American "low-priced three". Following the present-day trend in America with regard to length, low height and high rated horsepower, it is nevertheless thoroughly conventional in chassis design. It weighs about 3,850 lb and has a list price of about £1,000.

The Plymouth engine, the manufacture of which is the subject of this article, is typical of current American engine design. It is a compact, overhead-valve V-8 unit, with a bore and stroke of 3·91 in×3·31 in (99 mm×84 mm) and a displacement of 318 in^3 (5·2 litres). Its dry weight is about 640 lb and, with a compression ratio of 9·0 : 1, it is rated at 225 b.h.p. at 4,400 r.p.m. Other versions of this engine, with increased displacement, special carburettors, special camshafts, fuel injection and so on, are rated at up to 315 b.h.p.

In the Mound Road factory, in which these engines are manufactured, there is a floor area of 534,000 ft^2. The production capacity is 1,050 engines per eight-hour shift. On entering the buildings one is immediately impressed by the absence of stacks of material. Other than the few fork-lift trucks used to unload incoming castings and to load outgoing finished engines, there is little or no traffic in the aisles. Materials are moved from line to line by more than four miles of overhead conveyors, while conveyors under the floor carry dust and chips out to storage bins.

The methods used in machining the main engine components, such as the crankshaft, pistons, connecting rods, cylinder heads and cylinder block, is, of course, generally the same for all V-8 units. Accordingly, in this article, attention will be given mostly to departures from standard practice and to the methods by which the parts are handled. Of special interest is the fully-mechanized, semi-automatic line on which the engines are assembled and the unique methods used in the final testing of the completely finished engines.

Crankshafts and pistons

An area of 65,000 ft^2 is allocated to the crankshaft section of the plant, in which there are 107 machines. The steel crankshaft forgings are hand loaded into the conveyor system and are then fed automatically to the loading positions of each group of machines in turn. First the shafts are fed to one of a battery of Fitchburg milling machines, where locating faces are dry milled. Next the shafts are automatically carried to one or other of ten Wickes centre-drive lathes, where the main journals are turned. The crankpins are then turned and cheeked on a group of LeBlond crankshaft lathes. Subsequently, the oil holes are drilled and automatically inspected and the holes are drilled and reamed in the flywheel flange. Finally, the main journals and crankpins are ground on Landis machines, and polished to a tolerance of 0·0005 in.

The cast aluminium pistons, designed for automatic handling, are loaded into a separate conveyor system. They go first to a group of four Baird automatic lathes, where the outside is rough and finish turned and the ring grooves finish turned in just under 8 seconds; in these operations, the peripheral speed is 1,450 ft/min. Next, the grooves for the oil control rings are slotted and the gudgeon pin hole is rough and finish bored on a group of 23 Heald machines. The gudgeon pin holes are automatically gauged to a tolerance of 0·0003 in and, should any oversize or undersize holes be detected, the machine on which the defective component was made is automatically shut down. The peripheries of the pistons are ground and automatically held to size. Finally, after being washed, tin plated and brought to a standard weight, the finished components are automatically inspected and separated into five size groups, in steps of 0·0005 in, the group symbol being automatically stamped on the piston.

Connecting rods

Both the connecting rods and caps are forged and machined separately, except in the final operations. The first operation is the rough and finish grinding of first one side and then the

other side of the big-end and small-end bosses. This is done in one pass through each of two separate Blanchard surface grinders, each fitted with a control device that automatically compensates for wheel wear. Next, the rods are washed and carried to an automatic weighing machine, where they are placed in one of six weight groups, or rejected either as too heavy or too light. The big-end joint faces and semi-circular surfaces are then broached, and the small-end bosses are drilled and rough reamed. Subsequently, the joint faces are rough and finish ground. The last operations on the rod by itself are the drilling and reaming of the bolt holes, spot-facing the bolt bosses and milling the lock slots for the big-end bearing, and milling an oil groove.

Meanwhile the connecting rod caps pass through a series of Lapointe broaches, which rough finish their sides, the joint face and semi-circular surfaces and face the bolt bosses. Next, the joint face is semi-finish and finish ground on a Blanchard machine. Finally, the bolt bosses are drilled, chamfered and reamed and the lock slots for the big-end bearings are milled.

The next operation is especially interesting, in that the connecting rods and caps are completely assembled on a Gilman automatic machine. A conveyor brings the connecting-rods to this machine, and they are automatically set in position so that the bearing lock slots face the correct way. The caps also enter the machine and are turned into the appropriate position. Then the big-end bolts are pressed into place, the nuts loaded into wrenches and run down to the specified torque setting. The assembling machine incorporates a means for checking that the parts are present and that they are correctly delivered to the loading stations. It also checks the complete assembly of the connecting rod and rejects any units that are incomplete or incorrectly assembled. This checking avoids delays for rectification at a later stage of production and ensures that the finished product is reliable.

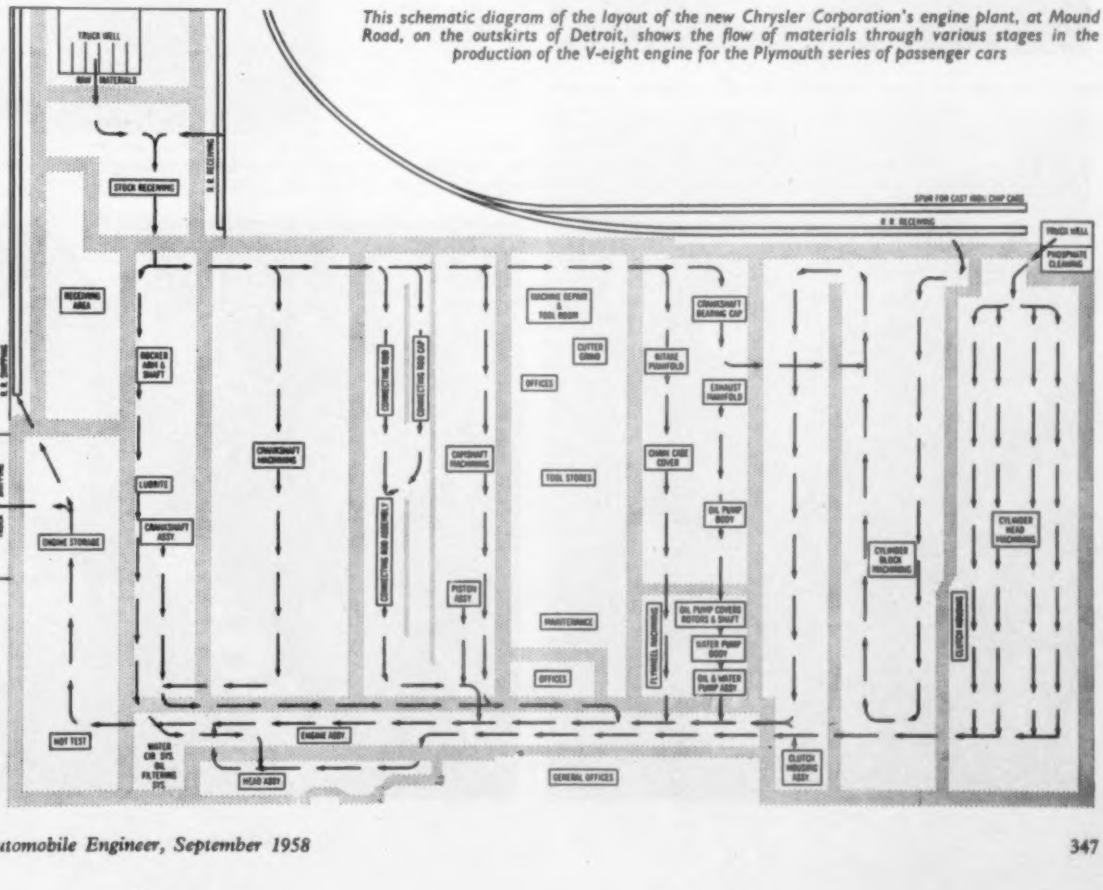
Blanchard automatic machines then grind the connecting-rod and cap on one side at both ends and on the opposite side at the big-end only. Next the gudgeon-pin bushing is pressed into place and burnished. The connecting rods are subsequently brought to a standard weight, by milling off material as required. After this, the big-end hole is bored and the gudgeon pin bushing is reamed on an Ex-Cell-O machine; both holes are automatically checked and, should they fail to pass inspection, the boring machine is automatically shut down.

Finally the big-end is honed on a Micromatic machine. The hones are rigidly mounted, while the connecting rods are permitted to float between two plates. The feeding-in, rotation, stroking and tool expansion are automatically controlled. After automatic numbering of the connecting rods and caps in pairs and in sets of eight, the big-end nuts are partly unscrewed. The piston and gudgeon pin are then assembled to the connecting rods, and the assemblies sent off in groups of eight to the engine assembly line.

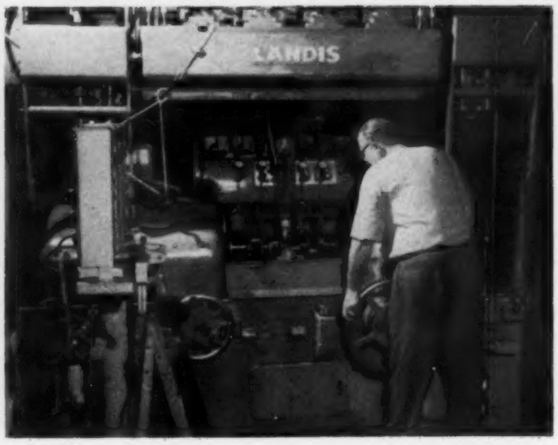
Cylinder blocks

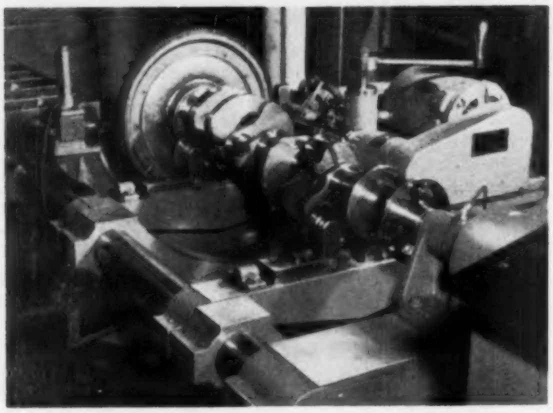
All the cylinder blocks are machined on two lines, each 1,380 ft long. Before they start on these lines, the blocks are spot checked, to ensure that cores have been correctly placed and that the castings will machine correctly. The first operation is carried out in an exceptionally large Cincinnati broaching machine, 59 ft long. In it, the cutting tools are moved through a stroke of 23 ft at a speed of 150 ft/min and are capable of taking off as much as ½ in of metal. In order to avoid chatter, the tool holders are mechanically, instead of hydraulically, driven.

On the first pass of the cutters, the cylinder blocks are machined on the top face and the two cylinder-bank faces. On

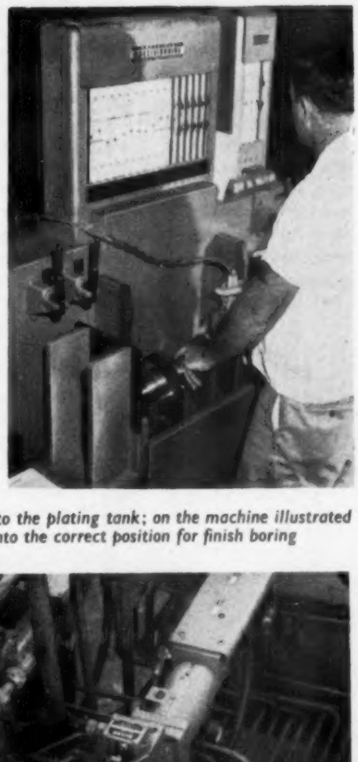


This schematic diagram of the layout of the new Chrysler Corporation's engine plant, at Mound Road, on the outskirts of Detroit, shows the flow of materials through various stages in the production of the V-eight engine for the Plymouth series of passenger cars





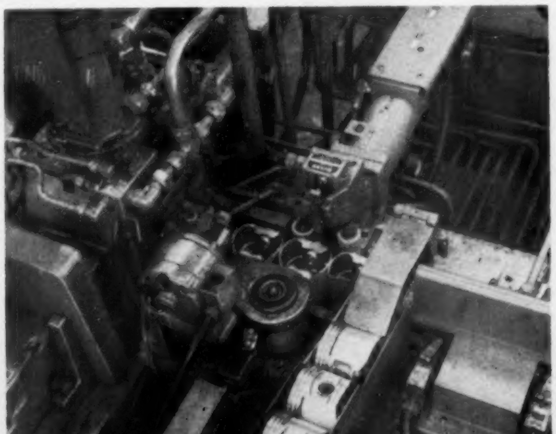
Above: The walking beam in the Wilson Automation crankshaft section, illustrated on the left, feeds the shafts downwards to the grinding machine shown in the right-hand illustration



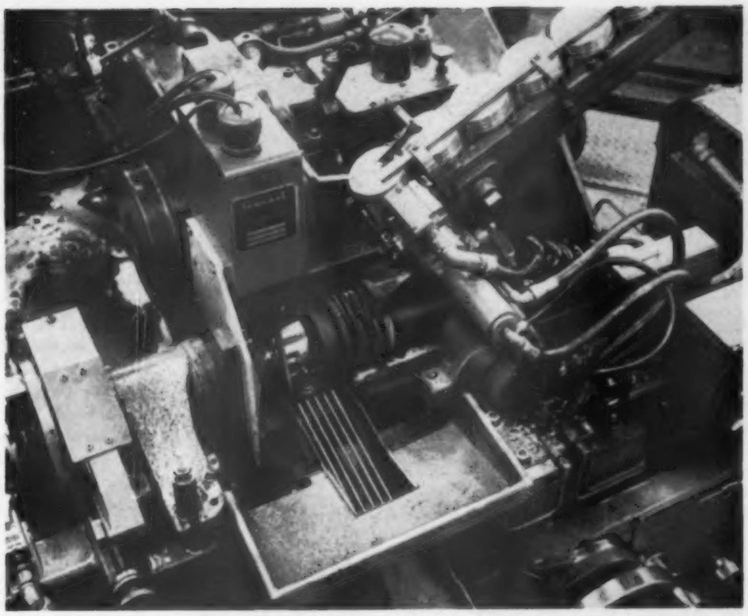
Right: Diameters of all the crankshaft journals are checked by Sheffield gauges

Above: The balancing of the complete crankshaft and flywheel assembly

Below: On the left is the 360 ft conveyor belt that transfers the pistons from the milling machines to the plating tank; on the machine illustrated on the right, the pistons are each automatically turned to bring the offset gudgeon pin hole into the correct position for finish boring



This Cincinnati, fully automatic machine is used to grind the piston skirts. The illustration shows the Federal electronic gauging head that controls the grinding wheel. A pivoted arm picks up the piston at the lower end of the shute and indexes it into position for chucking. These machines can be set to grind to any given dimension, to any surface finish, to the amount of taper desired, and to whatever elliptical form may be required



the return pass of the ram, the sump face and the locating pads are machined. Next, the blocks pass through a succession of five Greenlee transfer machines. The first is a 27-station machine, in which locating holes are drilled and the crankshaft bearings and cylinders rough bored. Then in the second, a 40-station machine, the ends of the cylinder block are faced and drilled, and the camshaft tunnel and two oil galleries are drilled. In the third Greenlee machine, with 29 stations, and the fourth, with 28 stations, all remaining holes, except the sump stud holes, are drilled and tapped, and the bank faces are machined. Finally, the 22 station fifth machine finishes the top and sump faces of the cylinder block, rough reams the distributor and oil pump drive bore, and drills and taps the sump stud holes.

At this point, the crankshaft bearing caps are installed, and finish-machining operations are started on a group of Ex-Cell-O machines. The cylinder bores and tappet holes are rough and finish bored and, in another machine, a number of surfaces that must be located in accurate mutual relationship are machined simultaneously at one setting. These machining operations include the boring of the camshaft bearings, the crankshaft bearing housings, the holes for the oil pump drive shaft and the distributor drive shaft, and two dowel holes in the rear face of the cylinder block; at the same time, the pad for the oil pump assembly is milled.

Finally, a finishing cut is taken, from the top face and the two cylinder-bank faces, in a Sunstrand milling machine, and then the bores are honed. Automatic inspection is carried out after each group of machining operations. Before tapping operations, all holes are automatically probed for presence and depth. In two more automatic operations, the core hole plugs are installed and each cylinder block is tested for water leaks.

The last operation is the passing of the finished cylinder blocks to a washing machine, where they progress through eight stations. At each station there are high-velocity jets of cleaning solution, arranged so that they clean all oilways and all parts of the blocks. Subsequently, each block is immersed in a tank of agitated cleaning solution, and is rinsed and then finally blown-out with air. All handling in this most thorough cleaning operation is automatic.

Cylinder heads

All the cylinder head machining is carried out on four parallel transfer machines, each 420 ft long. The arrangement is typical of present-day American cylinder head production methods, in that the cylinder head castings are

Right: Snyder crankshaft transfer machine, on which the oil holes are drilled. The groups of three heads deal with eight oil holes in the crankpin and main bearings; each head drills one-third of the depth of the hole and each hole is probed to ensure that it is finally drilled through. If an unfinished hole is found, signal lamps indicate the location of the fault. The machine head in the foreground is used to mill the locating slot in the flange. This slot is used, instead of the more usual dog, for driving purposes during the crankpin grinding operation performed later

The automatic assembly of the connecting rods and big end bearing caps

manually loaded on the conveyor and are scarcely seen again until they emerge fully-machined at the other end of the line. First the surfaces are broached, the machine cutting on both the out and return strokes, at a speed of 150 ft/min.

Next the cylinder heads enter a group of four separate Barnes transfer machines. The division of these machines into four sections is to minimize the difficulties that occur when machines must be stopped for tool changes and so on. At the end of each section is storage space, so that cylinder heads may be set aside or fed back into the line, as occasion demands. Cylinder heads may also be diverted from one line to another; they are under the control of an operator whose station is on a bridge that extends over all four lines.

On this bridge are mounted Barnes Detecto panels, for the rapid tracing of electrical trouble. The operator can quickly check each electrical circuit and contact by means of a probe, so that faults can be located and put right with the least possible loss of production time. Also, the transfer machines are arranged so far as possible with their spindles horizontal, for easy access; there is space between machines for tool changing or repair.

As they pass through the transfer machines, the cylinder heads have all holes drilled and, where necessary, tapped; also, the rocker-arm bracket pads are milled and the valve-spring seats hollow milled. Of special interest is the drilling and facing of the valve seat and valve-guide hole. First the valve seat is faced by a carbide cutter, then the valve-guide hole is drilled at a considerably higher speed, using the valve-seat cutter as a guide. The run out permitted between the seat and guide is 0·002 in, total indicator reading, but it is claimed that in practice the run-out rarely exceeds 0·0005 in.

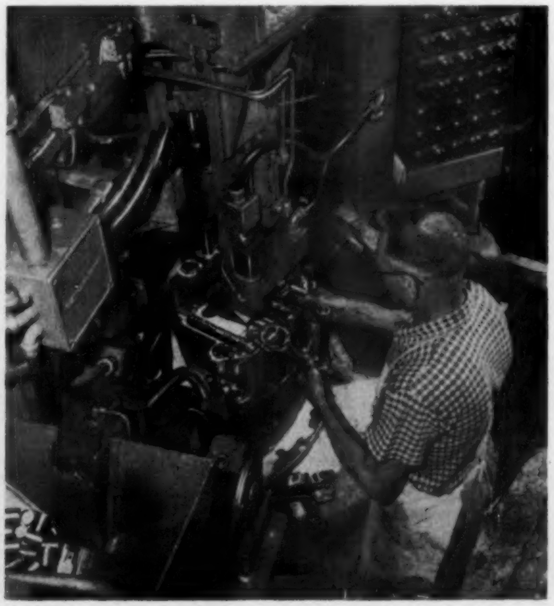
Finally the cylinder heads pass through an automatic leak testing machine, which blows air into the head and detects any drop in air pressure. Heads rejected by this machine are passed to a water test machine, in which the head under test is turned over for visual inspection.

Semi-automatic assembly

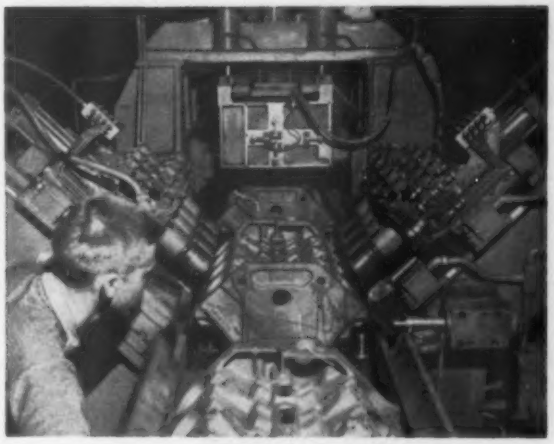
One of the two most interesting processes in this plant is the semi-automatic assembly of engines on a fully-mechanized line. This plant, designed and built by the Cross Company, consists of duplicate cylinder head assembly lines, each 120 ft long, and a final assembly line 565 ft long.

Cylinder blocks arrive at one end of the assembly line, on

A five-station, automatic indexing machine, shown below on the left, assembles the bushes into the small ends of the connecting rods. Loading is effected manually and the bushes, which are fed from a hopper, are orientated and pressed home by means of a hydraulic ram; then the bore of each bush is burnished and both extremities are chamfered. The illustration on the right shows a Buhr machine into which the connecting rods are manually loaded and automatically clamped for the drilling and rough reaming of the small ends; unloading is also effected automatically by the machine



Left: Semi-finish boring and chamfering of the cylinders on an Ex-Cell-O machine



Right: Plymouth engine cylinders being rough bored on a Greenlee transfer machine line

an overhead conveyor, and are placed each on its own pallet, upon which the block is accurately located. The pallets are moved forward 4 ft at a time, on a cycle that includes a 16 sec stop at each station and 8 sec for movement. Although most of the operations are automatic, some remain manual, usually on account of the difficulty in reaching certain bolts; therefore, in moving, the pallets are accelerated smoothly, so that the operator can finish his work while the engine begins to move off.

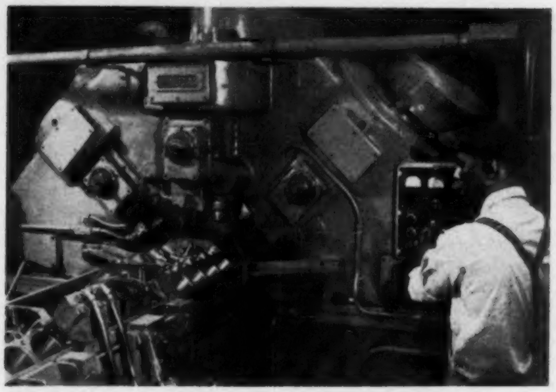
All tightening of nuts by machine is carried out by air-driven motors, which are mounted in manifolds. These manifolds are designed so that the motors can be changed rapidly, and adjustment of the torque to which the nut is to be tightened can be effected easily. Small parts and sub-assemblies are brought to the line by conveyors, which are timed so that the parts accompany the engine, for which they are intended, for the whole of the time until they have been assembled.

Well-established procedures are followed in the assembly of the engines, but in this plant manual work consists almost entirely of putting screws, bolts and sparking plugs initially in place: with few exceptions, all tightening is done by machine. This has the advantage that the assembly line workers are relieved of fatigue due to lifting and tightening, and each nut and bolt is accurately preloaded to the torque specified by the design department.

The first operation is the loosening of the main bearing caps by machine. Then the caps and screws are removed by hand, the crankshaft bearings are automatically sprayed with oil and the crankshaft assembly is automatically set in place. Next the caps are replaced by hand and the screws driven by machine. In the next operation, the camshaft is fitted in place, and the camshaft thrust plate, sprocket and chain cover screws are set and automatically tightened. The cylinder bores are then automatically sprayed with oil, the piston and connecting rod assemblies, which arrive on a rack at this point, are fitted in place by hand and the connecting rod bolts automatically tightened. Subsequently, the oil pump assembly and the oil filter and oil pan are set in place and their screws automatically tightened.

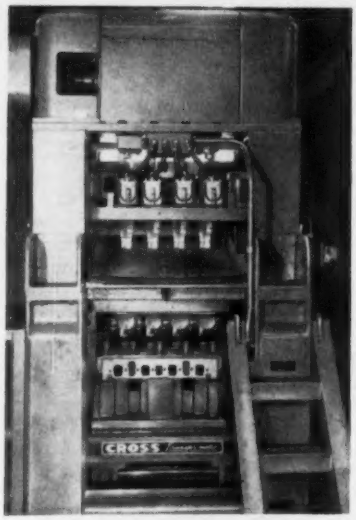
Meanwhile, the cylinder heads have been assembled on their own duplicate lines. First the valves, valve springs and spring retainers are automatically placed and secured, then the exhaust manifolds are placed by hand and the retaining nuts run down by machine. Finally the rocker-arm and shaft assemblies are placed by hand and their screws tightened

This Cincinnati broach is claimed to be the largest machine of its type in the world. It is 59 ft long × 19 ft wide × 12 ft high. Together with a slightly smaller machine, it completes in eight operations all the broaching on the V-8 engine, cast iron cylinder block

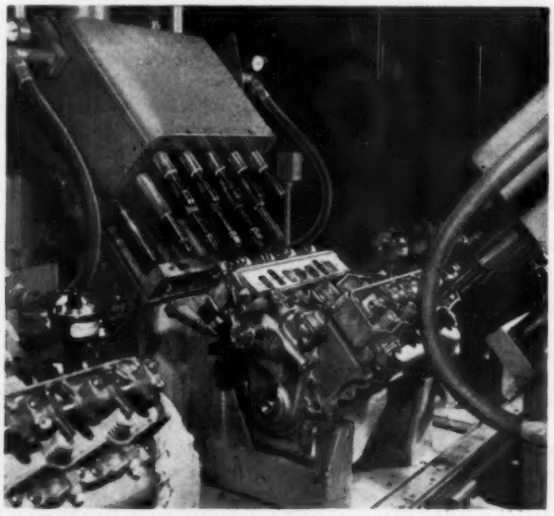


Sundstrand milling machine taking the finishing cut off the top face

Final checking of the cylinder block is effected on a Sheffield machine



Left: A Cross machine automatically assembles the valves, valve springs and their retainers



Right: The cylinder head bolts are tightened automatically on the Cross machine

Left: The two cylinder head transfer machine lines, their control bridge, and electrical fault-finding panels. A close-up of the control can be seen in the small illustration below

Below: One operator controls two cylinder head transfer lines from a bridge. He can store parts or switch them from one line to the other

by machine. The cylinder head assemblies are then automatically placed on the cylinder block, and their 17 screws each placed by hand and run down by machine. Finally, the intake manifolds and the cylinder head covers are assembled in position and their retaining nuts tightened.

Semi-automatic assembly of the pistons and connecting rods is shown in progress here on the Cross assembly line

Testing

The second interesting process in the manufacture of the Plymouth engines, and one that is probably unique, is the semi-automatic and fully mechanized testing of finished engines. Power units that enter the test department are completely assembled so far as the Mound Road Engine Plant is concerned: that is, they are painted and complete, except for the fan, carburettor, dynamo, starting motor and fuel pump. This is because it has been found more economical to add these parts to the assembly immediately before the engine is mounted in the chassis, and this operation takes place at another factory.

In the test department, which has been designed and built by the George L. Nankervis Company, there are three groups of test stands, with 24 stands in each. These are capable of testing 150 engines per hour, giving each engine a test lasting 20 minutes. The engines arrive from the engine assembly line on an overhead conveyor. They are automatically placed each on its own test pallet, and accurately located. As each pallet enters the test area, it immediately starts to seek out an empty test stand and keeps on going around until it finds one. No test stand will accept a tested engine.

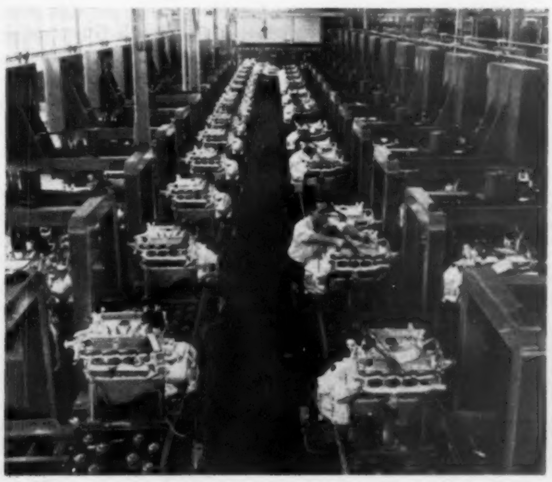
On arriving opposite an empty stand, the pallet is stopped and the engine is pulled into the stand, front-end first, and locked in place. At this point a series of air cylinders thrust connections for the various services towards the corresponding openings on the engine. These include connections for water, oil, the natural gas fuel, and the exhaust, and shafts for driving the water pump and to crank the engine. It is most interesting to see these connections being made in a matter of seconds, with no human intervention whatsoever.

The cycle starts with the slow engagement of the air-driven starter motor. This motor then turns the engine at about 450 r.p.m. for as long as 30 seconds, or until the engine is running under its own power. If for any reason the supply of fuel, oil or water be lacking, the machine will make no attempt to crank the engine, but will attract the attention of an inspector by illuminating a warning lamp on the control panel.

After running for about 17 minutes with lubricating oil flushing through, the external oil supply is cut off and the engine's own lubricating system takes over. At the same time, a light on the test stand signals an inspector that the engine is ready for its final check. The inspector then goes over the engine carefully, noting any oil or water leaks or any piston or tappet noises occurring when the engine is run up. Should he be satisfied that the test is completed, he makes a note of any faults on the engine inspection tag and presses the stop button on the test stand. The unit then stops, all connections are withdrawn and it is pushed out of the stand on to a tested-engine dolly, which is sent away for storage or shipping.

In this test all routine operations are taken over by the machine, and the operator has only to carry out those inspections that demand good hearing, good eyesight and intelligence. This policy, of course, is right in line with modern trends with regard to production and all its associated processes. It has been followed consistently throughout the whole of the planning of the new plant, as well as in the test department. Nevertheless, despite the fact that the new plant is one of the most up-to-date in the world, it is obvious that finality has not yet been reached and progress will continue.

Two rows of Nankervis semi-automatic engine test stands are shown in the illustration on the left, and a close-up view of one of the test benches is shown on the right. This installation is one of the outstanding features of the assembly plant. After undergoing an electrostatic painting process, the engines are moved, by means of a conveyor, to the test stands. They are then fed automatically with oil, water and natural gas, while they are run for a twenty-minute test cycle. On the completion of this cycle, the engines are moved to a storage area ready for transport to the car assembly plants



Outlook on Automobile Design

Some Leading Suggestions With Regard to the Way Ahead

GEORGES ROESCH, M.I.Mech.E., M.S.I.A., M.S.A.E.

As world competition intensifies, the need for thinking well ahead on design problems is greater than ever before. A prime requirement is that designs shall be as far advanced as possible in conception. Only in this way can a sufficient lead be obtained over competitors, so that production can be undertaken on a large scale over a long period, to minimize costs. Obviously, the exercise of the greatest possible foresight is necessary in order that designs of this type can be produced with the least possible risk. The aim must be not only at establishing the lead, but also at maintaining it.

Experience in times of industrial stress shows that body styling alone is not a potent enough factor for the maintenance of a firm's competitive position. Further, the high cost of retooling involved in changing body styling can only be recovered by large quantity production over an adequate length of time. The obvious solution, the production of a wide variety of models, incorporating existing components, tends to waste creative design staff and may give disappointing results.

A most important requirement is that servicing procedure and policy should be considered in detail during the early stages of design. Reliability and low servicing costs admittedly have to be established over a period before they have an impact on sales, but once a manufacturer's reputation has been built up, they have a marked effect on the demand for a particular make of car. Even ease of cleaning needs to be given detailed consideration when the vehicle is being designed.

A glance through the pages of the instruction book of almost any popular car will show that owners, the majority of whom are unskilled, are expected to take on responsibility, the magnitude of which they can hardly be expected to appreciate. First, there is the running-in procedure, which in my view is a manufacturing operation, done at the owner's risk and expense. Then there may be post-delivery checks to be carried out; surely the experts at the factory are best qualified to check the work carried out there, and it is wrong to rely on other organizations scattered all over the world to do it properly.

Each additional servicing operation carried out on the motor car introduces fresh possibilities of human error and therefore tends to make the car less reliable. There is still far too much servicing attention required after every thousand miles, and even after every five hundred miles. Much of this work can be avoided today, especially in view of the current availability of greatly improved materials.

In general, lightness should be aimed at in the design of almost all modern cars. This is because there are now few motorists either willing or able to meet the high costs of running cars that are too big in proportion to the useful space available inside their bodies, and which are consequently too heavy, difficult to handle, and have a high fuel consumption. The ability to manoeuvre effortlessly is becoming increasingly important as traffic conditions deteriorate. It follows that future requirements are for smaller and more powerful engines and lighter and more compact transmission systems. Overall reduction in weight has a number of beneficial effects: for example, as a consequence of weight reduction, rapid acceleration and deceleration, which are both so much needed now, are obtained reliably and at a low cost.

The author of this article, Georges Roesch, M.I.Mech.E., M.S.I.A., M.S.A.E., was born in Geneva at the time when the automobile industry was just beginning to come into existence on the Continent. He was educated at the College of Geneva while, in his spare time, serving his apprenticeship in his father's automobile repair shop. Next, he went to Paris, which was at that time the world's centre of the automobile and aviation industries; there he studied design under Marius Barbaroux and later under Louis Renault.

He came to England early in 1914 and joined the Daimler Co. Ltd. Then, in 1916, he became chief engineer with Clement-Talbot Ltd. His great opportunity came late in 1925, when the manufacture of cars at the Talbot factory came to a standstill owing to the severe post-war recession and the fierce competition in this country, which, in those days, came from both home and foreign manufacturers. He designed the light, simple and elegant Talbot 14/35 model, which had a 10 ft wheelbase and a six-cylinder, 1,666 cm³ engine. This he put into immediate production, an output of 1,000 cars being sanctioned before the prototype was built, let alone tested. The company made profits in 1927, and by then their output had reached a maximum of 100 cars per week.

In the 1930 Le Mans twenty-four hour race, two standard, four-seater Talbots, powered by 2¼ litre engine, with push rod actuated, overhead valves, were triumphant. In this, their first attempt, they defeated all the famous, costly and complicated supercharged sports cars of up to 7 litres capacity and more, which were specially designed for racing. Thus, to their commercial success was added, at hardly any cost, the beginning of a fine record in competitions. This result was obtained by thought directed towards design on simple and inexpensive lines, meticulously worked out on the drawing board. In this way, Georges Roesch discovered, without resort to costly experiments that his firm could not afford, that large increases of power and lower specific fuel consumption could be obtained from an engine simply by employing a higher compression ratio and increasing the engine speed; at the same time, reliability, smoothness and silence, unknown before and still not realized fully even today, were obtained.

During the war, Georges Roesch joined Power Jets (R. and D.) Ltd., and later became chief mechanical engineer at the National Gas Turbine Establishment. Currently, he is advising on the development of small industrial gas turbines for the Ministry of Supply — a work that is closely related to the evolution of internal combustion engines and their transmissions.

For liquid-cooled engines, reliable anti-freeze mixtures are essential, and careful attention should be paid to cooling systems, to make them proof against leaks and deterioration of hoses. The system should also be designed so that the liquid cannot leak or overflow. Then it would be practicable to fill the system with anti-freeze solution at the factory, and draining would be required only after major servicing operations.

It is of interest to note that even as early as 1930, the Talbot 90, which gained first place in the Le Mans Index of Performance, had a pressurized cooling system integral with the engine, the radiator being mounted directly and rigidly on the cylinder block. Another interesting feature of the cooling system was that the pump spindle was gear-driven and its bearings were pressure lubricated. Only the fan was driven by a belt.

Certainly there is a case for re-examining cooling arrangements: the layouts currently in use, with their perishable, flexible connections and the large relative movement between the engine and radiator, leave much to be desired. It should also be possible to arrange the drives so that failure of the fan

belt does not also imply breakdown of the drives to the water pump and the dynamo. Although it is necessary to dissipate surplus heat when the engine is running, heat should be conserved the moment the engine stops. There is, therefore, a great deal to be said for insulating bonnets against thermal losses and, incidentally, noise. A thermostatically-controlled shutter or blind in the radiator grille is highly desirable as a means of increasing thermal efficiency and reducing engine wear.

Engine starting is an operation that is noisy and objectionable, particularly late at night. Currently, most engines have flywheels that are of larger diameter than their clutches, simply to accommodate a starter ring gear. If the flywheels were reduced to the same diameter as the clutches, the engines could be installed lower, and this would lead to a lower centre of gravity of the car. It is obvious, therefore, that fresh thinking is required on the subject of engine starting. There seems to be no point in not providing a starting handle, since a crank of some sort is needed for operating the jack and removing wheel nut or nuts: it is not difficult to design a handle so that it can be used for all three functions, without any sacrifice in respect of either cost or weight. With a very light car, the engine can be easily turned, for timing, by pushing the car in top gear.

Body layout should be the first consideration in the design of a vehicle. Comfort and convenience of the passengers, as well as of the driver, must be given far greater attention. Surely there can be no reason for the wide differences between the types of seats and shape of upholstery currently to be found in motor cars. The cant rails should be high, not only in order that the occupants can enter and leave the vehicle easily, but also so that the upper edges of the windows can be high enough to give a good range of visibility. The public seems to be so accustomed to the inconvenience and danger of wide pillars and indifferent ventilators on each side of the windscreen that serious attempts to improve these features have apparently been hitherto regarded as unnecessary. But what a pleasure it is to drive a car without a blind spot.

Good ventilation without the need for opening windows is an attractive amenity. This obviates draughts and is particularly useful in many foreign countries, in that it enables the car to be completely sealed against the entry of dust. It is doubtful whether the complication of a refrigeration plant could be justified in this country in the foreseeable future, but there is a demand for it in hot countries.

Attractive lines can always be obtained without excessive chromium plated decoration. The use of chromium plated garnishings tends to aggravate corrosion difficulties. Bumpers should not be fitted in such a way that, if they are hit, they inflict severe damage on the adjacent panelling. Among the other features that need careful study, so far as body design is concerned, are quietness and absence of vibration and road noise. These are all essential requirements.

Effortless control is most desirable. As power : weight ratios and maximum speeds increase, this will become even more important. It also has a considerable bearing on comfort, since comfort implies, among other things, absence of fatigue on long journeys. Reduction to a minimum, of the effort required to operate all the controls applies particularly to steering, which should also be sensitive in its response to the driver's control. The accuracy with which the car can be steered should not be affected in any way by the attitude of the wheels, under dynamic loading, in relation to both the body and the road. Other essential qualities are a neutral steering characteristic and freedom from kick-back through the control. Both these features are influenced by the manner in which the vehicle structure is connected to the wheels and by the steering geometry. The state of knowledge of these subjects at present is such that there is no difficulty in obtaining these qualities, and their absence from some modern cars can therefore be stated to be unpardonable.

Unsprung weight should be reduced to a minimum. Not only will this give good road-holding and suspension characteristics, but also, since the stresses transmitted to the structure will be correspondingly reduced, it will be possible to make the vehicle still lighter, and the shock absorbers will have to dissipate less energy. Some of the tyres, with synthetic rubber tubes, currently available perform extremely well, and do not even require topping up with air from one year to the next.

Automatic gearboxes have been developed to a fairly advanced stage on the other side of the Atlantic, but it is not always realized that transmissions of this type were first evolved in Europe. It is interesting to note that some of the automatic transmissions offered by British manufacturers are fitted with an over-riding control. Admittedly, a great deal of thought has been devoted to transmission development, but it would appear that less costly and lighter mechanisms could be developed. Fast and foolproof gear changes were made by the automatic preselector arrangement installed on Roesch-designed Talbot cars before the war. With this device, it was only necessary to preselect first gear. Then, by pressing a pedal, all the gears could be engaged successively up to top, and back to third and up to top again, without moving so much as a finger off the steering wheel. The preselector lever was an over-riding control. An essential safety feature of this gearbox was that, although the clutch was automatic, the engine was at all times connected to the transmission so long as any gear was in engagement — an indispensable feature in my view.

There is considerable room for improvement in electrical equipment. The battery should be instrumented to warn the driver when it requires attention. Contact breaker points have not yet reached the same stage of reliability as sparking plugs. A great deal more can be done to ensure that reflectors remain unaffected by atmospheric conditions. Alignment of headlamps should be made even more easy to effect, and the adjustment devices should be so installed that they do not become contaminated with mud and corroded.

With regard to design in general, the best results can only be obtained by meticulous attention to every detail of construction and manufacture. This increases prime costs slightly, but results in a car infinitely more economical to run and pleasant in the hands of the user. So far as production is concerned, efficiency is first determined by the quality of the original design, and satisfactory results can only be obtained by the employment of the finest tools available: this means that manufacture must be planned on the largest practicable scale. It should be remembered that the more advanced the design, the easier it is to begin by selling in relatively large quantities at a high price, and reducing the price as the demand, and consequently output, increases. Although standardization can help in facilitating long production runs, it can lead to stagnation so far as design is concerned. All these factors need careful consideration if the fast-growing foreign competition is to be met successfully.

Private Coachwork Competition

DETAILS of the Private Coachwork Competition, organized by the Institute of British Carriage and Automobile Manufacturers, are now available. As in previous years, this Competition will be held in conjunction with the International Motor Exhibition at Earls Court in October.

The aim of the competition is at encouraging improvement in the design, construction, finish and equipment of British coachwork. Three prizes are offered in each of the fifteen sections of the Competition: they are the Institute's Gold, Silver, and Bronze Medals. Entry forms can be obtained from Secretary of the Institute, 51 Pall Mall, London, S.W.1.

Rippon Vacuum Brake

The Zero Lag System, Which is Designed to Obviate Delay in Operation

H. C. Rippon, A.M.I.P.E.*

STILL the most popular form of power braking, the vacuum servo brake has one serious drawback. This is the time lag between the operation of the control and the effect, if the pipelines are long. This can be serious with heavy vehicles, so manufacturers endeavour to lay out the components in a manner such that the pipelines are as short as possible, and to avoid sharp bends and joints. At a vacuum of 29 inches of mercury, the corresponding pressure is 14·2 lb/in^2; however, the vacuum available is usually less than this, and a figure of 10 lb/in^2 is generally used in brake calculations. When a trailer or semi-trailer is coupled to a power unit, the length of the pipelines is an even more serious handicap, because it is possible to apply the power unit brakes fully, before the trailer brakes have been applied; some delay is inevitable, because of the low pressure differential.

Tests on articulated vehicles have shown that there may be as much as 1 or 2 seconds' delay between operation of the pedal and the application of the trailer brakes. In wet weather, the results can be very serious: when the power unit brakes are applied fully, the power unit speed is immediately reduced, but the semi-trailer is unchecked until the time lag is overcome; therefore, during this initial brief period, the semi-trailer exerts a forward push on the king pin and may force the power unit into a skid, usually resulting in a jack-knife effect.

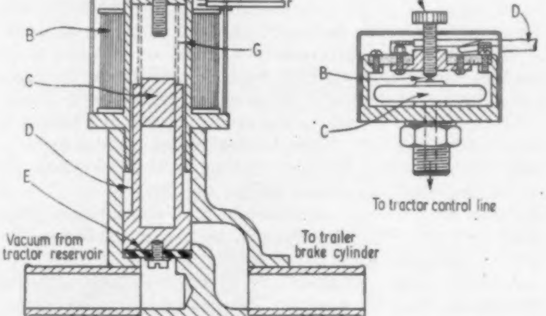
A new vacuum circuit has been developed, which almost completely overcomes this time lag of the trailer brake application, and can, in fact, be applied to all vehicles with vacuum brakes. This layout is shown in the accompanying diagram. In essence, application of the control causes the electrically actuated valve to open a subsidiary vacuum line to apply the trailer brakes; then, when the main control line has been adequately exhausted, the vacuum switch cuts off the current to the electric valve, which consequently closes. Regulation of the trailer brakes is subsequently effected in the normal manner, by the main control valve.

The important feature of the system is the electric solenoid actuated valve, which, when the brake pedal is depressed, opens instantaneously, to supply the trailer brakes with vacuum through a pipeline connected directly to a reservoir on the power unit. In a second pipeline to the trailer brakes, which is connected to the valve operated by the foot brake on the power unit, there is a sensitive vacuum switch, which cuts out the solenoid valve when vacuum from the valve actuated by the foot brake reaches a predetermined figure; then the trailer brakes are under full control of the normal brake system, by means of which the vacuum supplied to all the brakes is regulated in proportion to the load applied at the pedal.

In the illustration showing a cross section through the solenoid valve, which is wired into the stop-lamp circuit, the valve, with its rubber facing, is seated. When the current is applied, the valve is immediately pulled off the seating and allows the vacuum to exhaust the trailer brake operating cylinder. A screw adjuster limits the stroke of the valve spindle. This adjuster is of non-magnetic material, namely, brass, to prevent the valve from sticking owing to residual magnetism.

Another illustration shows the vacuum switch. This comprises simply a casing in which there are two contacts, one on a screw adjuster and the other secured to the top of an

* *Vehicle consultant, of Rippon Bros., Woodend Avenue, Speke, Liverpool 24.*

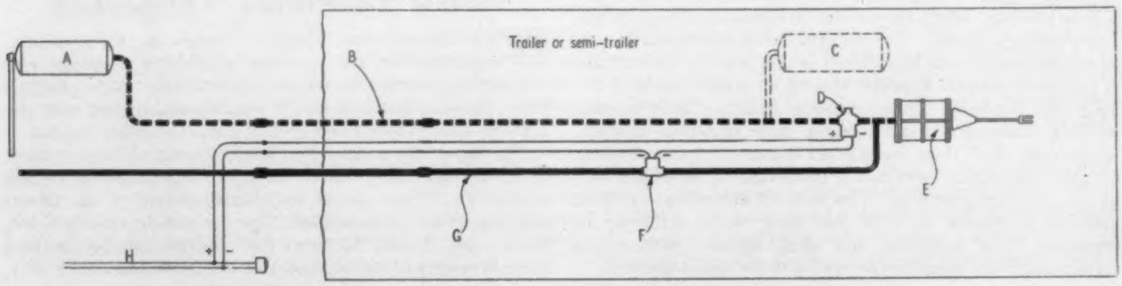


Key to left-hand diagram: **A** *stroke adjustment screw;* **B** *solenoid coil;* **C** *iron core;* **D** *valve spindle;* **E** *rubber seal;* **F** *electric leads;* **G** *spring*
Key to right-hand diagram: **A** *cut-out adjustment;* **B** *contacts;* **C** *capsule;* **D** *electric leads*

Above: Cross sections of the electric valve, which is shown on the left, and the vacuum relay, which is illustrated on the right

Below: Diagram showing the layout of the Rippon Zero Lag vacuum brake system. The components additional to the conventional vacuum system are: the pipe represented by the heavy dotted line, vacuum relay, electric valve, and in certain applications, the additional reservoir

A *reservoir on the tractor:* **B** *feeder pipeline:* **C** *additional reservoir, if required, on trailer:* **D** *electric valve:* **E** *trailer vacuum cylinder:* **F** *vacuum relay:* **G** *pipeline of the conventional brake system:* **H** *electric circuit of the stop lamp*



aneroid capsule. When a vacuum is applied to the casing, the contact on the aneroid moves down away from the adjustable contact, the amount of movement depending on the degree of vacuum. The upper contact can be set so that the switch will open and break the circuit at any required degree of vacuum, up to 30 in of mercury. Initial adjustment of the vacuum switch is effected by setting the contacts to break at 15 in of mercury or approximately $7\frac{1}{2}$ lb/in². Subsequently, the setting can be altered to suit individual requirements for different applications.

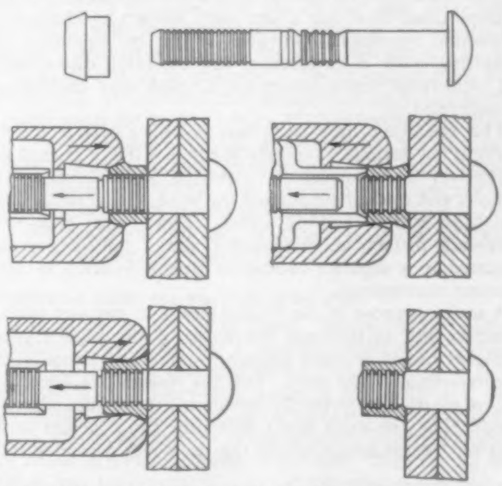
The operational sequence is as follows. Immediately the driver depresses the foot brake on the power unit, the solenoid valve on the trailer is opened. The trailer brake operating cylinder begins its stroke, to apply the trailer brakes, while vacuum is still being delivered through the normal foot brake valve through to the trailer. Next, the vacuum switch, set to cut out at $7\frac{1}{2}$ lb/in², breaks the circuit to the solenoid valve, so that the trailer brakes are then solely under control of the foot brake valve on the power unit. The total time for the completion of this whole sequence is approximately one second. When the foot brake is released, current is cut off completely and air admitted to the pipeline, to neutralize the vacuum, thus allowing the contacts on the vacuum switch to close ready for the next operation.

Any single-acting vacuum system can be adapted for the new layout. The additional components required are: an extra pipeline to the power unit reservoir, one vacuum switch and one solenoid valve. Fitting presents no difficulty, and synchronization can be carried out in about fifteen minutes. The layout is the subject of patents, and the components are available from the patentees, Rippon Bros., Victory Works, Woodend Avenue, Speke, Liverpool 24.

AVDEL LOCKBOLT

THE Avdel Lockbolt can be used to replace conventional components, such as nuts and bolts, or solid rivets, for the fabrication of metal structures. Its principal advantage is claimed to be rapid assembly: the Lockbolt can be driven with high-speed pneumatically operated hand tools. Driving is completely automatic, so skilled labour is not required. Other advantages claimed are as follows. The bolt is positively and mechanically self-locking. It has high shear and tension strengths, as well as fatigue resistance. Pre-tensioning is automatically effected uniformly. Its clench and sealing qualities are good and, so far as design is concerned, it is not necessary to allow clearance for a spanner. The assembly operation is quiet by comparison with that of riveting.

This Lockbolt assembly comprises a locking collar and a headed bolt, the shank of which has a series of annular locking, breakneck and pull grooves. The bolt is inserted into the hole in the workpiece, and the locking collar placed over its protruding end. A pull-gun is then applied, the jaws in its nose automatically gripping the pull grooves round the protruding end of the bolt. When the trigger of the gun is actuated, an axial pull is exerted on the bolt and is reacted against the locking collar by means of the swaging anvil of the pull-gun. This causes the assembly to be clenched tightly together. As the pull on the bolt continues, the anvil of the gun is drawn over the collar, swaging and locking it into the lock grooves of the bolt. This forms a permanent and rigid lock. Finally, the pull breaks off the end of the bolt at the breakneck groove. Thus, the Locknut is positively set at a predetermined tension. The gun then automatically disengages itself from the swaged collar. It is claimed that an unskilled operator can place up to 30 bolts per minute.



The upper illustration is of the Avdel Lockbolt and its locking collar. Of the remaining four diagrams, that at the top on the left shows the pull-gun applied to the bolt and collar, which have been assembled on the workpiece, the illustration below this shows the swaging anvil of the gun moving over the collar, and in the top right-hand illustration the end of the bolt is being pulled off at the breakneck groove. The remaining diagram shows the completed Avdel Lockbolt and collar assembly

Initially, these bolts are being produced in steel and high strength aluminium alloy, $\frac{3}{16}$ in and $\frac{1}{4}$ in diameter. The manufacturers are Aviation Developments Ltd., of Kingsbourne House, 229, High Holborn, London W.C.1.

Phase and Continuity Indicator

PEAK voltage sequence in three-phase supply lines can be checked by a new pocket instrument produced by Tiltman Langley Ltd., of Redhill Aerodrome, Surrey. The instrument can also be used, of course, to identify broken lines. It provides visual signals by means of five neon lamps.

The whole unit is continuously rated, and three of the lamps are arranged so that if the lines under test are live, all three lamps light up. In the event of one line being dead, the lamp associated with that line lights up, while the others remain unlit. Provided that all the lines being tested are sound, phase sequence is shown by one or other of the two remaining lamps lighting up. A point worth noting is that phase and line continuity are indicated by different lamps.

Flying leads, terminating in insulated clips or interchangeable test probes, are fitted to the instrument, which has a stowage compartment for this equipment. The dimensions of the instrument are $3 \times 2 \times 1\frac{1}{4}$ in. All the electrical components are embedded in resin; nevertheless, the weight of the unit is only 4 oz. A noteworthy feature of the unit is that it has no moving parts and is extremely sturdy. One version caters for three-phase, 115/200 volts, 400 c/sec, A.C. current, and another for 400 volt, 50/60 c/sec.

New Plant and Tools

Recent Developments in Production Equipment

WHILE lapping, polishing, and similar operations will reduce surface roughness, they are likely to exercise little influence on waviness irregularities generated during machining or grinding. The Wavometer is an instrument produced by Micrometrical Manufacturing Co., Michigan, U.S.A., for measuring waviness on symmetrical surfaces of rotation, either internal or external, up to 18 in diameter. Provision is made for angular adjustments of the worktable up to 30 deg above or 70 deg below horizontal. It gives meter readings of the r.m.s. average height of the waves, in two wave-bands, directly in microinches.

Requiring no technical knowledge or special skill to operate, the instrument can be used to ascertain what is accomplished in steps taken to obtain a less wavy surface by changes in production operations. Further, it can be employed for measuring work in production and assembly departments and identifying unsatisfactory parts before they are finished or assembled.

The operating unit comprises a motor-driven spindle carrying the necessary linkages to rotate a tracer around the workpiece; a motor-driven, elevating head housing the spindle; and a stand supporting the head, the worktable and the push-button control panel. Low- and high-band microinch meters, an oscilloscope and a loudspeaker are mounted in a separate cabinet to permit location to meet operator convenience.

A major purpose of the Wavometer is to measure surface waviness and to facilitate the study of the phenomenon. Different causes produce different numbers of waves on the circumference of the work. For this reason, two microinch meters are used to divide the waviness into two measurement bands. The low-band meter shows the r.m.s. height of the long-wavelength irregularities, that is, waves occurring from 4 to 17 times on the circumference of the work. For example, pockets caused by grinding the work in a multiple-jawed chuck will be included in the reading of this meter. The high-band meter shows the r.m.s. height of the finer waviness irregularities; those occurring 17 or more times on the circumference.

A visual representation of the waviness irregularities within either the low or high waveband is given by the oscilloscope. Selection of the desired waveband is by the switch to the left of the oscilloscope screen. The oscilloscope is synchronized with the spindle, and the length of the line on the screen represents the full circumference of the work. The oscilloscope pattern is not a true profile of the surface, but it shows the characteristics of the waviness contour within the limits of the wave-band being viewed. Thus it shows such things as whether the waves are evenly or irregularly spaced; whether some waves are higher or longer than others; and the number of waves per circumference within the high or low wave-band. The operator soon learns to interpret these findings in terms of defects or changes in the production operation that produced the surface.

The loudspeaker is mounted behind the grill in the front of the amplimeter and provides an additional check on the character of the surface being measured. It translates the surface character into sounds that soon become familiar to the operator. Also, the operator can often relate these sounds to their causes in the production operation. A rapid clicking sound shows the presence of nicks, scratches or other random flaws which are of too short duration to be shown on the meters. The loudspeaker is also useful during set-up of the tracer, for indicating when the tip first contacts the work.

Micrometrical equipment is handled in Britain by Gaston E. Marbaix Ltd., Vicarage Crescent, London, S.W.11.

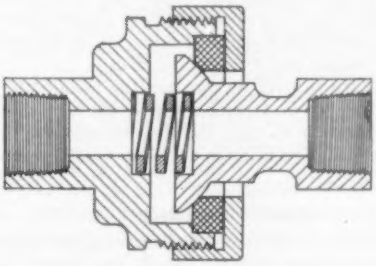
Micrometrical vertical Wavometer
Gaston E. Marbaix Ltd.

Self-sealing swivel joint

Inserted in otherwise rigid pipework, the Hilyn swivel joint will permit oscillation, rotation through 360 deg, and angular movement out of axial alignment up to 10 deg in any direction. In any position there is no restriction of flow and sealing is effected by internal pressure. Pre-tension to ensure the pressure-tightness of the joint at very low or zero internal pressure is provided by a helical compression spring located between the stationary and movable elements.

Constructionally the joint is simple and comprises five component parts only. Mounted in the mouth of the hollow body of the stationary member and retained by the cap nut, the sealing ring is of polytetrafluoroethylene. On this ring seats the part-spherically profiled head of the movable member. Tests have shown that the joint will hold pressures of steam, air, and water exceeding 2,500 lb/in^2. Standard types in gunmetal for industrial use are, however, conservatively rated at 500 lb/in^2, for steam, and temperatures up to 250 deg C.

Hilyn Industrial Equipment Ltd., Lockfield Avenue, Brimsdown, Enfield, Middlesex, produce both elbow and straight types in sizes ranging from $\frac{1}{4}$ in B.S.P. to 6 in B.S.P. Sizes up to 2 in B.S.P. are available from stock and the larger sizes are manufactured to order. For applications in which gunmetal is unsuitable, joints can be supplied in malleable iron, aluminium, or stainless steel.

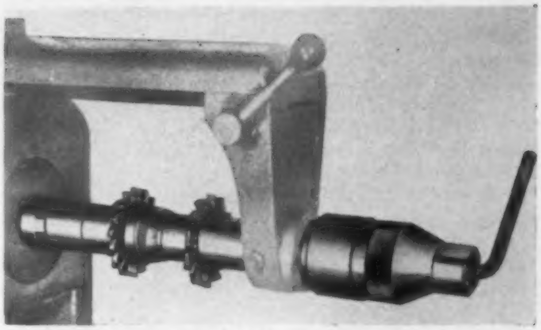


Self-sealing, swivelling pipe joint
Hilyn Industrial Equipment Ltd.

Hydraulic arbor nut

To tighten up an arbor assembly carrying one or more cutters it is fairly common practice to use a long spanner and a heavy hammer. A device to render such a crude method unnecessary should be welcomed. The Euco hydraulic nut enables a high pressure, up to 40 tons, to be applied with manual control. Replacing the original arbor nut, the hydraulic nut is merely screwed up hand tight and the clamping pressure is then applied by turning an Allen type key. Spanners and hammers are no longer required and the operation is performed quickly and without effort. Removal of the nut is as easily accomplished.

The nut consists of a body bored to form a small diameter chamber opening into a larger diameter chamber. These chambers are filled with a rubber compound which functions in similar manner to a liquid system but is free from leakage problems. A $\frac{3}{8}$ in diameter Allen type screw, equipped with a steel ball in the nose, is screwed into the end of the small chamber. This ball locates on a steel thrust pad bearing on the rubber compound. Pressure is transmitted by the compound to a second steel thrust pad in the larger chamber and thence to six hardened steel plungers. The plungers are slidable in a cage screwed into the larger chamber and threaded internally to fit the machine arbor. A cupped cover plate transmits pressure from the plungers to the arbor.



Hydraulic arbor nut
Euco Tools Ltd.

Any machine on which the arbor nut is located outside the arbor support can be fitted with the hydraulic nut. It can also be used to advantage on slitting and strip-rolling machines, and on woodworking machine spindles. The standard production range is for arbor threads of $\frac{3}{4}$ in, $\frac{7}{8}$ in, 1 in, $1\frac{1}{4}$ in and $1\frac{1}{2}$ in diameter. The manufacturers, Euco Tools, Ltd., 44 London Road, Kingston, Surrey, also produce a safety collar for milling arbors. This is intended to prevent the over-tightening of the nut which may occur if an unkeyed cutter momentarily stalls in operation. The safety collar is conventional except for the provision of a permanently fixed key instead of the usual keyway. It is placed between the cutter and the nut and, of course, is usable with either hydraulic or ordinary nuts.

Universal table for shaping machine

The scope of the 30 in stroke Invicta Major shaping machine is extended by a recently introduced universal table. Mounted in the usual manner on the cross slide and provided with a heavy-duty support, the table is a deep, box-section casting. A tilting top surface, measuring 18 in × $12\frac{1}{2}$ in, can be adjusted to 15 deg in either direction from the horizontal in a plane parallel to the ram. With the tilt table zeroed, the maximum distance of the table below the ram is $14\frac{5}{8}$ in.

In a plane normal to the ram the complete table unit can be turned through 90 deg to present a T-slotted side surface, $18\frac{7}{8}$ in × $14\frac{1}{2}$ in to the underside of the ram. This provides, in effect, a worktable of the standard type having a maximum distance of $16\frac{1}{2}$ in beneath the ram.

Universal table for shaper
B. Elliott and Co. Ltd.

Tilting and swivelling machine vice

This machine vice, recently introduced by A. A. Jones and Shipman Ltd. Narborough Road South, Leicester, has been designed to withstand heavy loading. Identified as Model 1712, it is built of Meehanite iron castings throughout and fitted with hardened and ground steel jaws. The central locking shaft and screws are of high tensile steel, engaged by nuts of phosphor bronze.

Jaws are 4 in wide × 1¼ in deep and work up to a maximum width of 3 in is admitted. Overall length and width are 12 in and 10 in respectively, the base width being 7¼ in. Tilting and swivelling adjustments, accurately scaled, provide for 90 deg movement in a vertical plane and 360 deg in the horizontal plane.

Auxiliary and master circular locking nuts on the Acme-threaded lock shaft are operated by means of a tommy bar. The auxiliary nut locks the swivelling base, leaving the tilting member free. A solid lock to both swivelling and tilting movements is effected by the master nut.

Tilting and swivelling vice
A. A. Jones and Shipman Ltd.

Injection nozzle servicing bench

A bench specially designed to facilitate the routine servicing of fuel injection nozzles for diesel engines is now produced by Leslie Hartridge Ltd. of Buckingham. The first has been supplied to the Rover Co. Ltd.

Dimensions are 8 ft long × 4 ft 6 in high × 20 in wide, and the construction is of mild steel angle and sheet metal, with a plastic-surfaced splash back panel. The top of the bench is fitted with two stainless steel sinks, with large draining surfaces providing ample working space. The interior, which is accessible by two large panel doors, houses tanks, circulating pumps and filters.

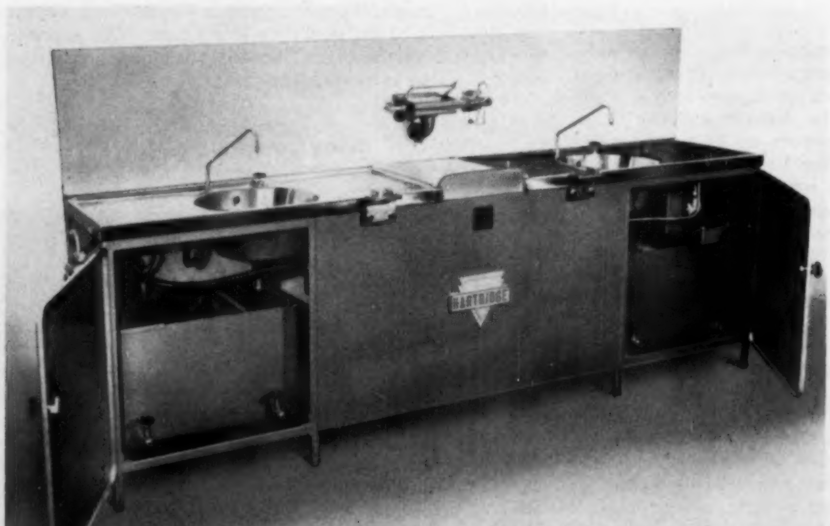
The left-hand sink is intended for cleansing the exteriors of nozzles and nozzle holders prior to dismantling. Fitted over the sink is a spout which directs a continuous flow of filtered cleaning oil at a low pressure from a large-capacity settling tank under bench. Nozzle holders are placed in the dismantling jig, fitted close at hand on the bench top, and the nozzles quickly and easily removed without any risk of damage. On the right is a sink for cleaning nozzles and nozzle holders prior to re-assembly. The facilities for this are exactly as for the left-hand sink, but the cleaning oil is delivered from a second large settling tank.

Attached to the centre of the plastic splash panel is a small nozzle-cleaning fitment which encloses the nozzle body under a Perspex inspection cover. By a single movement of a nearby lever, the nozzle body is clamped and a stream of either compressed air or cleaning oil is injected through the inlet conduit and the spray orifices.

Holders are cleaned by pressing the inlet on to a tapered nipple. This action depresses the nipple to release a stream of compressed air to clear the fuel passage and the interior of the holder. The nozzles are then finally reassembled in a second jig.

Ferrolux iron-powder electrodes

Iron-powder electrodes, it is claimed, improve productivity by giving increased welding speeds and longer run lengths than conventional electrodes. A new electrode of this type, termed the Ferrolux, is manufactured by Quasi-Arc Ltd., Bilston, Staffordshire, for the high-speed welding of mild steel in the flat and horizontal-vertical positions. It can be used with either A.C. or D.C. welding plants. When D.C. current is employed, the electrode should be connected to the positive pole.



Servicing bench for fuel injectors
Leslie Hartridge Ltd.

Using a touch-welding technique, the electrode can be drawn out to make long, smooth fillet welds. Fillets are mitre-shaped with a neat ripple, and slag detachability is good. The electrodes are extruded and are supplied in 18 in lengths in sizes ranging from 10 S.W.G. to $\frac{1}{4}$ in diameter. To ensure instantaneous arc striking, they are lightly tipped at the appropriate end with a special composition.

Conforming to the requirements of B.S. 639:1952, test specimens of weld metal yield the following typical results: Yield stress, 29 ton/in^2; ultimate tensile stress, 34 ton/in^2; elongation, 28·5 per cent; reduction in area, 48 per cent; Izod impact value (V-notch), 63 ft-lb; bend test, over 180 deg without failure.

Electromagnetic drill post

For the maintenance, repair, or installation of plant, the Wolf-H. & S. drill post can bring high-speed power drilling to otherwise difficult or hazardous locations. It will cut the time required for setting up and clamping an ordinary post and eliminate time-wasting and possibly imprecise hand drilling. Manufactured by Wolf Electric Tools Ltd., Hanger Lane, London, W.5, it is produced in two models to accommodate the firm's $\frac{3}{8}$ in and $\frac{3}{4}$ in capacity, high-duty "WD" type drills. With the magnetic drill post they can be operated in any position; vertical, horizontal, or inverted.

As regards the column and headstock, the post resembles an ordinary bench-type drill press. The base, however, houses powerful electromagnets, centred directly below the column and controlled by a two-stage switch mounted alongside. This provides a "holding" magnetic value, permitting accurate positioning of the equipment over the point of drilling. The switch is then advanced to the "drilling" position, to fully energize the magnets and also to bring the tool into circuit. Drills can be operated on full load and at maximum capacity and the positive rack-and-pinion feed facilitates accurate results with the minimum of effort.

By releasing the handle on the end of the column, the headstock can be swung round the column for lateral adjustment. This handle also serves for carrying purposes. A safety chain is provided as an insurance against a power failure or the inadvertent operation of the magnet switch. A saddle to enable the post to be used on pipes and other curved surfaces can be supplied.

Wolf-H. & S. electromagnetic drill post
Wolf Electric Tools Ltd.

The equipment is available in five standard voltages, from 100 to 250 D.C. and 25, 50, and 60 cycles A.C. A 50 V model is produced to special order.

UNIFIED SCREW THREADS

The International System is Rapidly Displacing Whitworth and B.S.F. Threads

THE Fourth Plenary Session of the International Standards Organization, held during June of this year in Harrogate, was attended by delegations from 38 countries. This session provided an opportunity for further discussions on international screw-thread standards and it was decided to recommend to the ISO Council that there should be two internationally recognized screw-thread systems. These are the unified inch series of threads, the use of which is already widely established wherever the decimal inch is the standard engineering unit of measurement, and the recently agreed metric series of pitch-diameter combinations to be adopted by countries using the metric system, though as yet it exists only on paper.

An outstanding feature of the discussions was the weight of evidence submitted by the American and the Canadian delegations showing that in both countries Unified Screw Threads have completely superseded the earlier American National Coarse series and the American National Fine series. Manufacturers exporting their products to North America would benefit, it would seem, by the adoption of unified threads in any equipment they offer.

It is reported by Guest Keen and Nettlefolds (Midlands) Ltd., of Birmingham, that a recent survey made within the British fasteners industry has shown that the use of unified threads for precision bolts and nuts is increasing rapidly in Britain. The automobile, petroleum, and agricultural engineering industries are all using large quantities, and other industries are gradually adopting them. Twice as many precision bolts and nuts of all grades, and machine screws of $\frac{1}{4}$ in diameter and over, are currently being purchased with unified threads as with Whitworth or B.S.F. threads. Furthermore, now that the British Standard 2708 for Normal Series Unified Black Bolts has been published, there is an increasing demand for unified threads on that type of bolt.

While important sections of industry will continue to use B.A. threads for machine screws smaller than $\frac{1}{4}$ in diameter, the demand for small screws with unified form and pitch to the American standard is rising. Already it represents about 10 per cent of the total demand. There appears little doubt that the unified screw thread has become established as one of the important thread systems in use in Britain and that it will eventually displace both Whitworth and B.S.F. systems.

Unified threads have gained support in Scandinavia and Holland, and at least one Swedish manufacturer has changed from metric threads to unified inch threads. On the European continent generally it is probable that metric threads will remain as the first choice. However, the metric countries are now following the example of America, Britain and Canada in unifying their standards which, hitherto, have differed from country to country.

MECHANIZED HEAT TREATMENT

The Firth-Derihon Stampings Ltd. Batching Plant at Darley Dale

WHEN the Darley Dale works was built in the 1941/42 period of World War II, conditions then obtaining necessitated the installation of a coke-fired producer gas plant to operate in conjunction with producer gas-fired, forge-reheating furnaces and small batch-type, heat-treatment furnaces. These operated satisfactorily up to 1956. At that time the need for much greater accuracy of heat treatment procedure to deal with the whole range of the highest quality alloy and carbon steels, nickel-based alloys and titanium alloys, together with increasing maintenance requirements of the gas producer plant, impelled the decision to change over to the use of town gas for all furnace firing and to modernize the furnace equipment.

Until then, the Darley Dale works and the parent works at Tinsley, Sheffield 9, had been individually responsible for the heat treatment of their own production. It was decided, however, to instal a completely new heat-treatment plant of adequate capacity at the Darley Dale works, and to concentrate there the whole of the heat-treatment requirements of the Company.

The first stage in the modernization programme was the laying of a 12 mile long × 15 in diameter high-pressure town gas main from Chesterfield to the Darley Dale works, the installation of a new high-capacity, town gas meter and governor house, and extensive modification of the internal-distribution gas main.

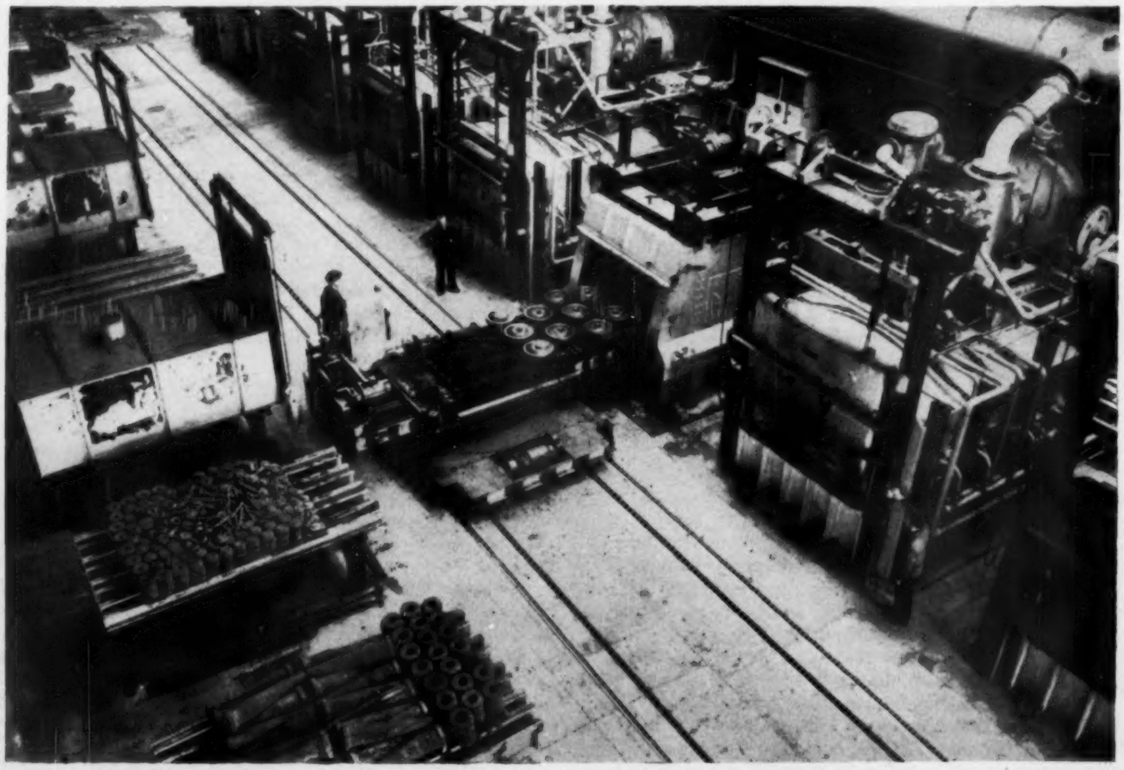
The commissioning of this central plant, which is comparable technically with modern installations in Europe, has resulted in a reduction of 50 per cent of the labour force previously employed on heat treatment, and also a reduction of 75 per cent in the number of heat-treatment furnaces previously operated.

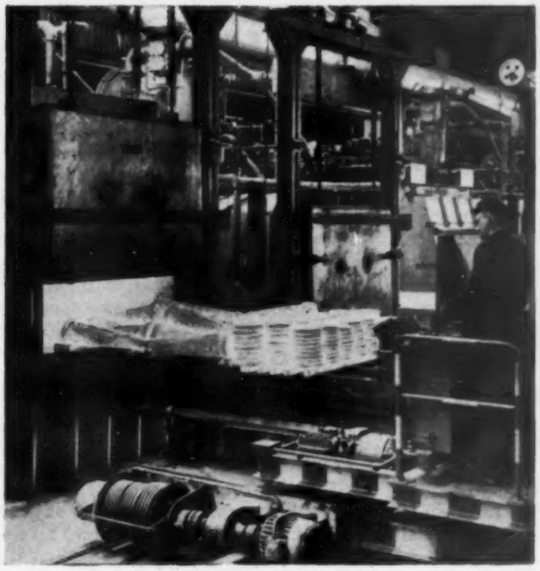
The new plant, incorporating many advanced features, was designed jointly with Gibbons Bros. Ltd., Honeywell Brown Ltd., Hartons Ltd., and members of the Brown-Firth Research Laboratory. It comprises:

3 Gibbons dual-system, town gas-fired, heat-treatment furnaces
2 Gibbons town gas-fired tempering furnaces
1 Gibbons oil-quench machine
1 Gibbons-Van Marle turntable charging machine
1 Instrument and control room
1 Centralized waste gas discharge system
Slow-cooling chambers, forced air cooling tables and loading tables.

All the furnaces have dimensions of 11 ft 0 in length, 6 ft 6 in width and a height of 3 ft 3 in to the spring line of the arch in the doorways. Furnace loads up to 5 tons in

The general layout of the new heat-treatment plant. On the near side of the rotating charging machine are loading tables, slow-cooling chambers and forced air cooling tables. The rotating charging machine is withdrawing a batch of turbine discs from the oil quench machine. On the far side of the charging machine, located from left to right, are the instrument control house, recirculating tempering furnaces, two dual-system furnaces, oil quench machine, dual system furnace and recirculating low temperature furnace





Half-shafts and crown wheels being withdrawn from a dual-system furnace prior to transfer to a forced-air cooling table

Forgings being transferred by the rotating charging machine from a dual-system furnace to the oil quench machine

weight are accommodated. Dual-system furnaces have normal operating temperature ranges of 200-750 deg C with forced recirculation, and 750-1,250 deg C without forced recirculation. Tempering furnaces, with forced recirculation, have normal temperature ranges of 200-750 deg C.

Furnace temperatures are electronically controlled by a fully automatic electro-pneumatic system, the Honeywell-Brown control instruments being housed in a centrally located, air-conditioned control room. The dual-system furnaces are single-zone controlled, and the tempering furnaces are two-zone controlled. Temperature distribution throughout the furnaces is held to extremely fine limits and is indicated and recorded at any six points in each furnace.

All furnaces are fully instrumented and controlled to safeguard against failure for any reason. Compressed air for the operation of the pneumatic control equipment is supplied by duplex air compressors and receiver units mounted on top of the control room. These compressor units are automatically controlled from the room below. Kent gas-flow recorders are used to record the gas-flow rates, and the total gas consumption, of each furnace. Waste gases from the furnaces are collected through a centralized, overhead, waste-gas main and then discharged into the atmosphere by a high-capacity, waste-gas fan delivering to an exhaust stack.

The oil quench machine is of the fully enclosed type with automatic door operation. Automatic lowering and lifting of the load, with variable-controlled oscillation of the load during the quench period is also incorporated. This ensures the optimum oil flow conditions during the quenching cycle. For cooling the oil in the quench machine, the oil is drawn from the top of the tank; passed through a water-cooled oil cooler and returned to the tank by way of distribution ducts in the tank base. The oil cooler is capable of dealing with 27,000 gallons of oil per hour, using 12,000 gallons of water per hour. Oil temperature is shown by an indicator on the discharge pipes from the oil tank.

The charging machine used in conjunction with the loading tables, furnaces and oil quench machine is an all-electric, four-arm, turntable design, capable of handling 5-ton loads. Four motors are used for lifting, lowering, charging and discharging, traversing and rotation. Power is supplied to the charging machine by means of a specially designed motorized cable-drum unit mounted on the charging machine. The feed cable is laid down in a small duct below floor level.

Incoming materials are received into the reception bay in stillaged form. Diesel-engined forklift trucks and electric battery-operated stillage trucks are used for the movement of the stillaged loads into the storage area, and between the storage area and the loading tables. After treatment, the work is again stillaged and is trucked to the adjacent inspection department. In the main heat-treatment bay, electric overhead cranes are used for assembling the heavier forgings on the loading tables. Dependent on the weight and section of the forgings to be treated they are loaded into special heat-resisting furnace trays or on to heat-resisting bearer-bars. After the load has been assembled on the loading table it operates as a unit load throughout all subsequent operations in the heat-treatment department.

In general, the plant has been laid out to handle large and small batch production efficiently and to eliminate manual handling, as it has to deal with a wide range of forgings varying in weight from a few ounces up to about 800 pounds.

INDUSTRIAL PURCHASING

THE full text of the lectures given by Professor Howard T. Lewis, of Harvard University, at the Advanced Purchasing Course conducted by The Purchasing Officers Association at Christ Church, Oxford in April, 1958, is now available in booklet form. In these lectures Professor Lewis deals with the increasing importance of purchasing as a management function, and with the latest American techniques applied to Forward Buying, Value Analysis, Vendor Relations, and Purchasing Performance Evaluation.

Short papers on each of these subjects by British authorities are also included, together with individual comments on the lecturer's points and his replies. Three very detailed case problems are presented, followed by Professor Lewis's analysis of their solution. The booklet can be obtained from The Purchasing Officers Association, Wardrobe court, 146A, Queen Victoria Street, London, E.C.4, price 10s. 6d.

"POLYORC BH" TUBING

A New Product in High-Impact, Rigid P.V.C. by Yorkshire Imperial Metals Ltd.

NORMAL types of rigid P.V.C. have always suffered the disadvantage of being somewhat brittle, and this characteristic has prevented their use for applications where both non-corrosive properties and robustness are required. High-impact, rigid P.V.C. is a relatively new compound, originally developed in the U.S.A., production of which commenced in Great Britain in March 1957. It represents the highly successful outcome of research to increase the shock resistance of rigid P.V.C. whilst retaining, as far as possible, its exceptional chemical resistance.

The impact strength of the new material is from 10 to 15 times greater than that of normal, unplasticized P.V.C. Reductions in maximum safe-operating temperature and in resistance to certain chemicals are compensated for by a lower specific gravity and the greatly increased impact strength.

Advantages

The great majority of the advantageous characteristics of rigid P.V.C. are possessed by the new material. Corrosion resistance, light specific weight, non-ageing and weathering characteristics, non-inflammability, chemical inertness, and resistance to scale build-up are all retained. In most cases, therefore, high-impact P.V.C. can be used for applications for which normal P.V.C. has previously been used or recommended and, in addition, can be used where exceptional resistance to shock is also essential. Salient properties of the new material are:—

Impact strength—15 ft-lb per inch of notch, Izod. (This makes it at least 10 to 15 times stronger than normal P.V.C.)

Tensile strength—6,000 lb/in^2. (This value is slightly less than that of normal P.V.C.)

Softening point—70-75 deg C

Co-efficient of expansion—10×10^{-5} per deg C

Chemical resistance—Resistant to acids and alkalis. (Affected by concentrated acids, more readily swelled by common solvents)

Flammability—Does not support combustion

Specific gravity—1·35

Tubes and fittings in a wide range of nominal bores up to 4 in diameter are now being manufactured by Yorkshire Imperial Metals Ltd., of Leeds.

Applications

Its light weight, corrosion resistance, non-inflammability and rigidity has already attracted the interest of shipowners and shipbuilders, for use in cold fresh and salt water services, sanitary services, sounding pipes and vent pipes. Although more expensive than galvanized iron or steel pipes, the savings in weight and maintenance expenses can easily offset the initial cost. The ease of manipulation and installation, when compared to metal pipes, should also effect savings. This will be more pronounced as plumbers and pipe fitters become more experienced and skilful in the manipulation of tubes made from high-impact P.V.C.

The potential industrial uses to which tubes in this new material can be put are widespread. With very few exceptions, most corrosive liquids can be conveyed with absolute safety, at room temperature. Installations can be carried out with the minimum amount of effort and equipment, and maintenance is negligible.

For use in the motor car manufacturing industry, the use of tubing in this new material for pickling and plating solutions, industrial effluents, air-conditioning and ventilation, and also in battery manufacture can be readily considered. Another application is to pneumatic tubes for conveying messages and laboratory samples and some of these have been installed in "Polyorc BH" tubing and are operating in corrosive atmospheres. They are also more silent in operation than metal tubes.

Jointing, bending and manipulation

The jointing of "Polyorc BH" tubing can be effected by using a solvent adhesive with plain socket-ended fittings. This method has the advantage that thin gauge tube can be used where long straight runs are encountered.

The notch sensitivity of high impact tubing is not as great as with normal rigid P.V.C. and screwed tubes and fittings can be used. A B.S.P. taper thread should be cut on the tube, the fittings having a B.S.P. parallel thread, and the joint may be made dry. If a permanent joint is desired, a solvent cement can be applied to the threads. Other types of jointing compound, or hemp, should not be used. Only heavy, screwing-size tube should be used for this method and care should be taken that all the threads are fully engaged.

The bending of tubes up to 4 in nominal bore is best accomplished by filling the tube with fine dry sand and applying heat evenly to the tube in the area of the bend. The ideal way of applying heat is by infra-red heaters, or from a radiant heat source, but in small bore tubes the careful use of a blowlamp will be found satisfactory.

When the heated area has been sufficiently softened, the tube can be bent in the hands in the case of small bore tubing (or alternatively with the use of a bending spring); round a former for tubes of medium size, 1½ in to 2½ in nominal bore; or by being eased into position on a bending table where larger tubes of from 2½ in to 4 in nominal bore are involved. Cooling and setting into position can be done by either immersing in cold water or by pouring cold water over the tube.

Examples of different jointing methods for "Polyorc BH" tubing. From top to bottom—cemented spigot, cemented sleeve and screwed fitting

CURRENT PATENTS

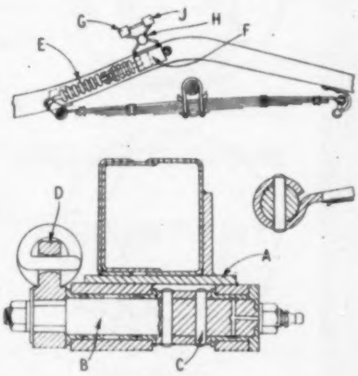
A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

Ride leveller for leaf springs

This levelling device for adjusting the riding height of a vehicle to compensate for changes of the load carried can be applied to conventional suspension systems with a minimum of changes to existing structures. The rear end of the spring is connected to the frame by a shackle and a C-shaped spring hanger. At the front end, the anchorage bracket A has spaced, aligned bores which are bushed to receive a cross shaft B. Positioned between the laterally spaced bushings, the spring eye is non-rotatably secured to the cross shaft by a pair of pins C.

At its inboard end shaft B is squared to receive a short lever D. Into the eye of this lever is hooked the end of tension spring E hingedly attached to the piston rod of a hydraulic cylinder unit F.

The magnitude of the force exerted on lever D is dependent upon the position of the piston in cylinder F. When the vehicle is loaded sufficiently to lower the



No. 790104

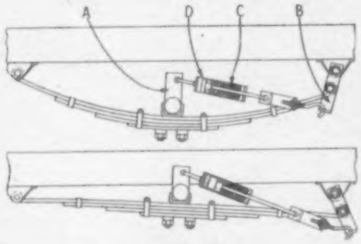
riding height, this height can be restored by movement of the piston to increase the tension on spring E. Thus torque is applied to the spring eye to raise the vehicle frame to the desired height.

Pressure fluid is supplied to the appropriate end of the cylinder by a pump G, indicated diagrammatically. A valve H, responsive to movement of the frame relative to the road wheel, controls fluid flows to and from the ends of the cylinder, and J is a reservoir for the return flow. *Patent No.* 790104. *Ford Motor Co. Ltd.*

Auxiliary springing device

In an otherwise conventional rear suspension system, the main spring is supplemented by an auxiliary spring, lying laterally either inboard or outboard of the main spring and constrained between a bracket above the axle casing and an extension arm depending from the rear shackle. The bracket A is secured to either the axle casing or to the spring pad and lever arm B is either mounted on the shackle or is an integral extension of the shackle.

The illustration shows a helical spring C operating in compression and incorporated in a damping cylinder D of either a



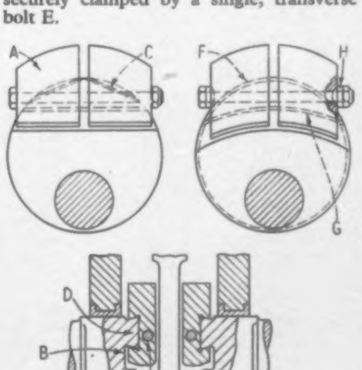
No. 790239

pneumatic or hydraulic type. Alternative layouts, referred to in the specification, employ unenclosed springs operating in tension or in compression. The linkage is adjustable by means of the screwed-shank hook at the rear connection. *Patent No.* 790239. *Toledo Woodhead Springs Ltd.*

Demountable counterweights for disc crankshafts

Particularly in relatively small engines, crankshaft counterweights are likely to restrict access to connecting rod and main bearings. In the case of disc-type crankshafts, threaded axially into tunnel crankcases, integral counterweights are likely to be of inadequate mass and demountable weights must be attached to the faces of the discs since the discs serve as the main journals. Axial drilling of the discs for this purpose presents difficulties. The invention provides for divided counterweights mounted on wedge-shaped surfaces on faces of the discs and clamped by transverse bolts. Two methods are illustrated.

A pair of half-weights A are provided on each web for each crank throw. The face of the disc web is grooved at B at right angles to the plane of symmetry including the crankpin, the outer wall of the groove being inclined to the web face. At an angle to the groove, similar but oppositely inclined faces C are machined on the periphery of the web. Half-weights A are machined with grooves corresponding to the wedge-shaped projections D remaining on the web, and on these they are securely clamped by a single, transverse bolt E.

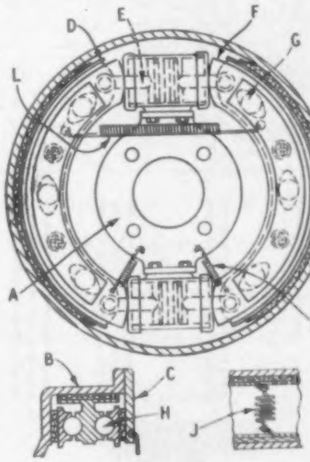


No. 790749

In the alternative attachment, arcuate surfaces F and G replace the plane surfaces of the previous example. As the half-weights have a pivoting movement relative to one another when the clamping bolt is tightened, part-spherical collars H are provided to prevent distortion of the bolt. *Patent No.* 790749. *Maschinenfabrik Augsburg-Nurnberg A.G.* (*Germany*).

Combined shoe and disc brake

Distribution of braking torque between a number of distinct friction elements results in a cooler-running brake. In this combined brake the shoe elements are applied by the operator and the reaction developed is used to apply the disc elements. The unit comprises a torque plate A bolted to the axle casing and a drum B mounted on the wheel hub. An



No. 790675

annular flange C is attached to the mouth of the drum and thus three working surfaces, one drum-type and two disc-type, are provided.

A pair of double-acting hydraulic brake cylinders are mounted on plate A and actuate shoes D through linked struts E. On each side of the web of a shoe is arranged a sector-shaped element F faced with friction material to engage respectively the drum wall and the annulus C. Camming devices G consists of opposed ramps in shoe and sector, each with an interposed ball H.

The profiled ends of sectors F extend beyond the web of the shoe to anchor and pivot on the ends of the brake cylinders. Tension springs J are connected between pairs of sectors to constrain them to the normally retracted position. The combined shoe and sector units are suspended vertically by springs K and are held to the upper brake cylinder by a spring L. *Patent No.* 790675. *Bendix Aviation Corporation* (U.S.A.).

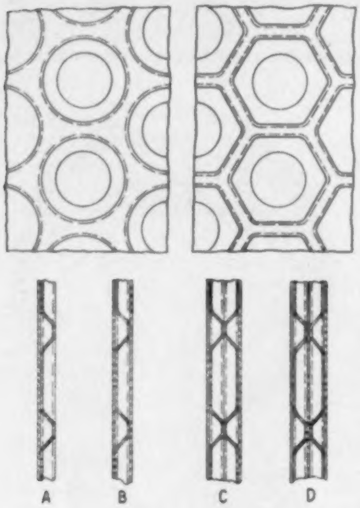
Composite panels of synthetic plastic material

Particularly, but not exclusively, intended for motor vehicle bodywork, this composite

panel comprises at least one layer with an unbroken surface and one layer formed with staggered lines of cup-like depressions of circular or hexagon shape and having inclined walls. Epoxide resins are suitable, hardenable materials and may be reinforced in known manner. The smooth external skin can, with appropriate selection of material and moulding procedure, be given a highly polished surface in the one operation.

Panels are light, easily produced, and can be made adequately stiff, especially in torsion. They enable practical advantage to be taken of the non-corroding properties, reduction of vibration and noise, insulation with respect to sound, heat, and electricity, suitability for tropical as well as temperate climates, and ease of repair, that are characteristic of the synthetic material. The use of circular or regular polygonal depressions ensures that resistance to bending is the same in all directions.

Preferably, the layers are fused together



No. 790253

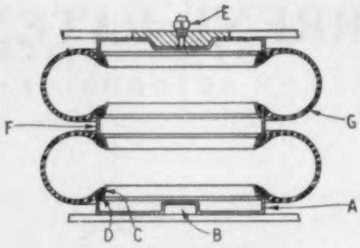
at areas of contact. If all layers are of the same material, fusion can be effected by assembling while still "wet" and then completing the hardening and shaping.

Of a number of variants, four constructional examples are shown. At A is a simple panel of the minimum two layers, while at B a plain sheet is provided on each side of a pressed sheet. Duplex panels have a pair of pressed sheets with a plain sheet on each side of the pair, as at C. The panel at D is similar to C but has a third plain sheet located between the two pressed sheets. *Patent No.* 790253. *Daimler-Benz A.G. (Germany).*

Pneumatic suspension spring

A particular object of this invention is the construction and arrangement of seatings and the co-operating seats of the tubular member so that under fluid pressure a sealing engagement is effected without the use of auxiliary clamping devices. Several forms are dealt with in the specification and in each there is provided a pair of spaced supports with a tubular fluid chamber arranged between.

In the example, the form of construction permits the use of existing equipment used in the manufacture of rims and tyres.



No. 786845

The lower cover A has a pressed-out central depression to engage the location boss B on the support plate, and a rolled annular flange of a section providing a bead-receiving seat C and shoulder D. Except that it is apertured to admit air by way of valve E, the upper cover is identical with the lower one, although in the diagram an alternatively shaped boss and depression is shown. Intermediate the two support plates is an annular rim F, rolled with seats and shoulders on both sides.

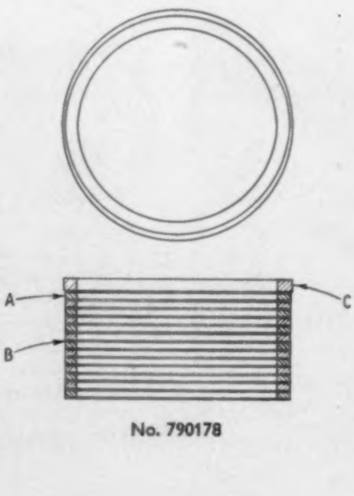
Mounted between the covers and rim F are two resilient members G, resembling tubeless tyres, formed with beads reinforced with inextensible bead wire. The metal parts can be stamped or rolled at low cost and do not require moulding or machining operations. *Patent No.* 786845. *Goodyear Tire and Rubber Co. (U.S.A.).*

Machining piston rings

Piston rings, finish machined on their faces, are assembled in a column, clamped together, and turned internally and externally to a shape suitable for producing the necessary tension when fitted in the engine cylinder. During the turning operation there is a risk of rings being displaced from their position in the assembled column.

This disadvantage is obviated by the method of the invention. When the blanks A are being assembled they are secured together by layers of adhesive B, of a type that can be removed subsequently by a solvent or by evaporation.

Since the blanks are not truly circular either before or after machining, circular centring rings C are secured to the ends of the column of blanks, also by adhesive. Such rings are at least 0·01 mm larger than the major diameter of the blanks. *Patent No.* 790178. *H. Teves and E. A. Teves (Germany).*

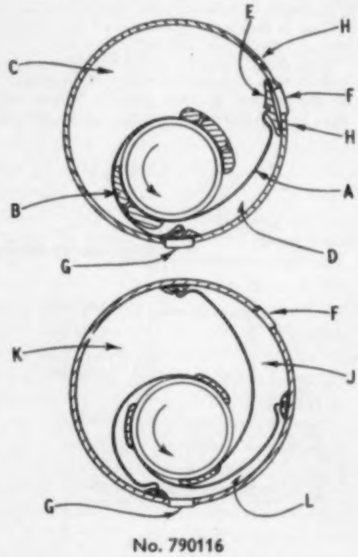


No. 790178

Positive displacement blower

This vane-type rotary blower, suggested as suitable for application as a charging-air or cooling-air blower for internal combustion engines, is remarkable by reason of the resilient sheet metal vanes which are a feature of the design. The vanes are always flexed in the same direction, and at all angular positions of the rotor the slippers are in advance, in the direction of rotation, of the point of attachment to the rotor. Any convenient number of vanes may be used and two-vane and three-vane units are shown diagrammatically.

In the first, two vanes A are clamped to the rotor at diametrically opposite points by cheeks B. The vanes are of phosphor bronze or spring steel and, with the rotor, divide the casing into two chambers C and D which continuously change in volume as the piston is rotated. Adjacent the outer end, each vane is bent to an S-shape so that the extreme end is approximately radial to the casing bore. This end engages



No. 790116

freely in a groove in the inner face of the slipper E. On its outer face the slipper is substantially flat and consequently engages the casing bore only at its leading and trailing edges. The slipper may be of a non-metallic material, such as nylon or polyurethane.

In the casing wall are rows of intake ports F and delivery ports G. In the position shown, chamber C is filled with air at atmospheric pressure while the air in chamber D is initially at a "residual" pressure approximating to the delivery pressure. Pressure equalization between the two chambers is effected by transfer through ports H.

The second example shows a three-vane model. The casing is furnished with similar intake ports F and delivery ports G, but in this instance by-pass ports are not required. Three chambers, intake J, compression K, and exhaust L, are formed by the vanes and during one revolution each chamber performs each function once. After the delivery ports are closed, the exhaust chamber enlarges to an extent that the residual pressure is reduced to admission pressure, at least, before the intake ports are opened. *Patent No.* 790116. *F. J. Dean (Britain) and Auto Union G.m.b.H. (Germany).*

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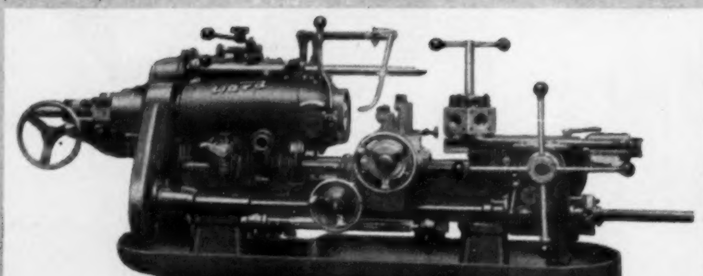

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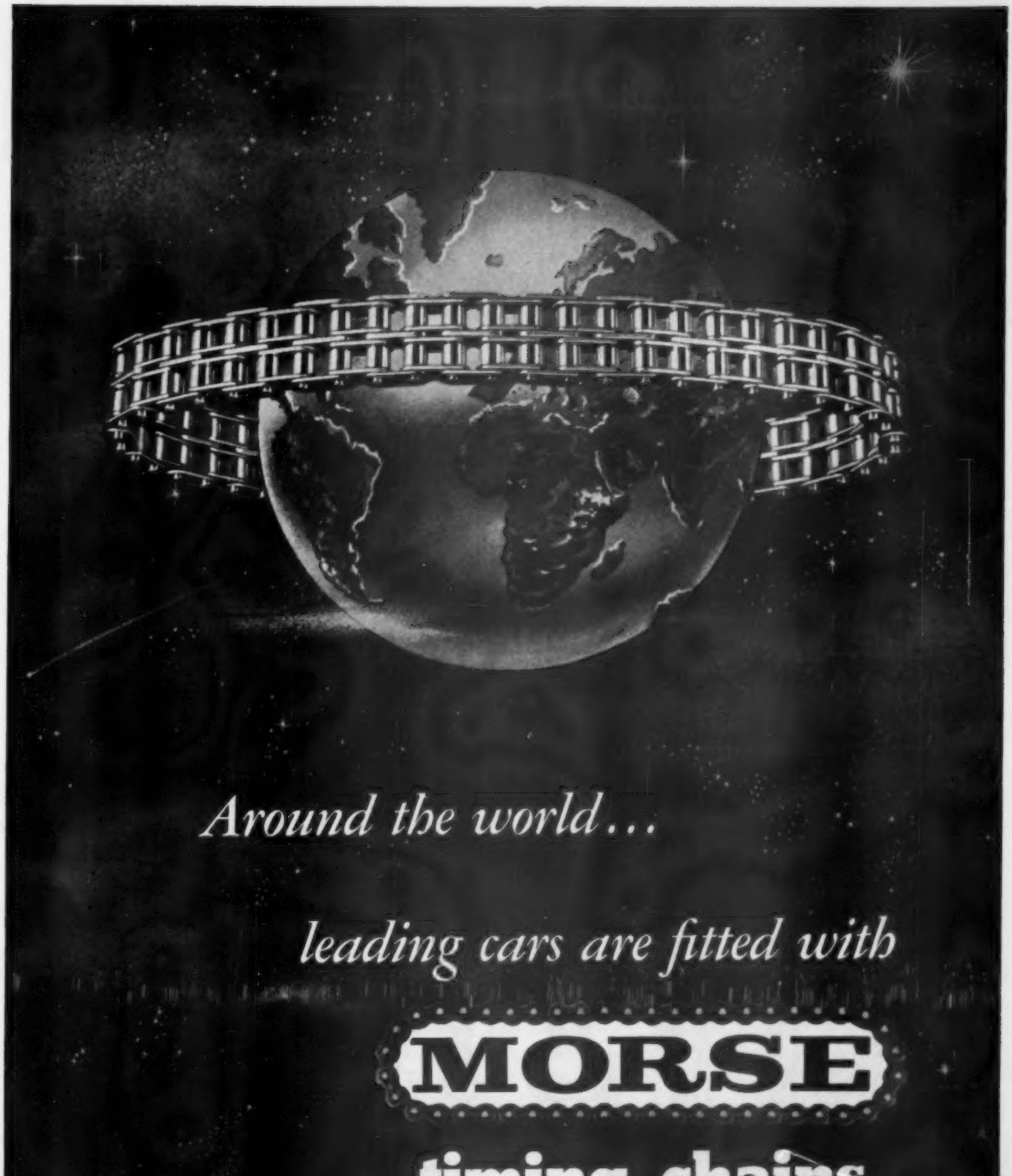
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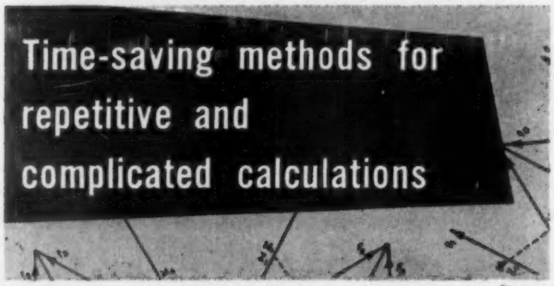

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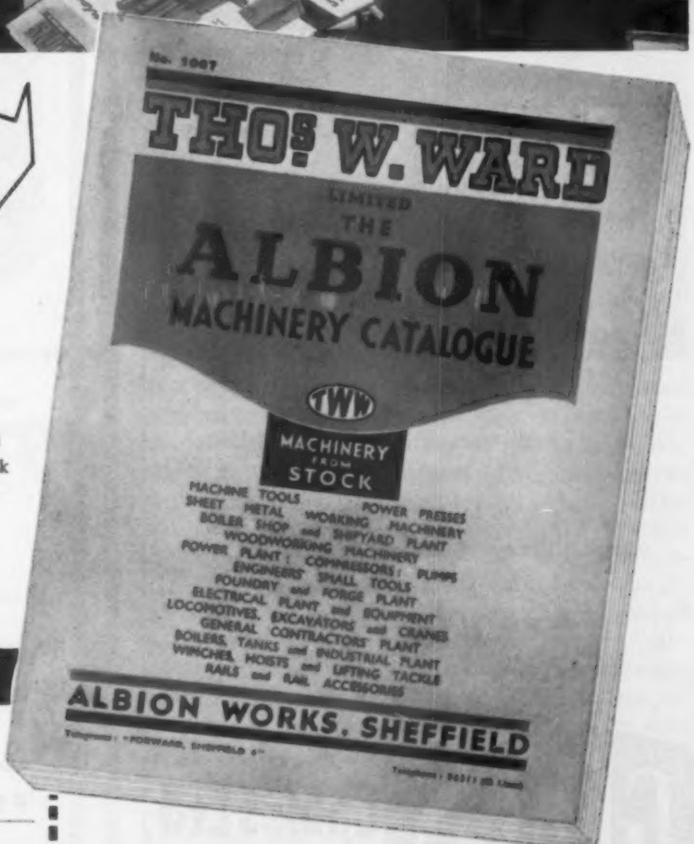

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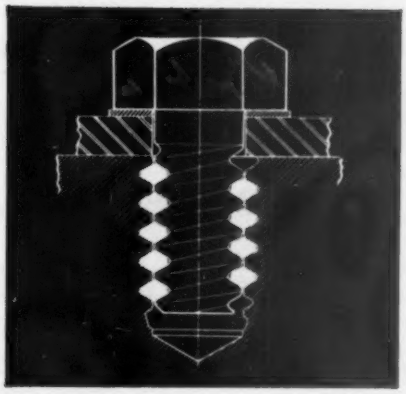

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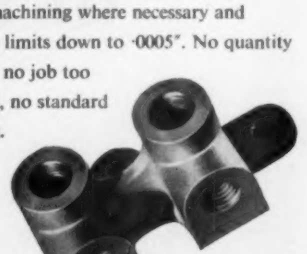

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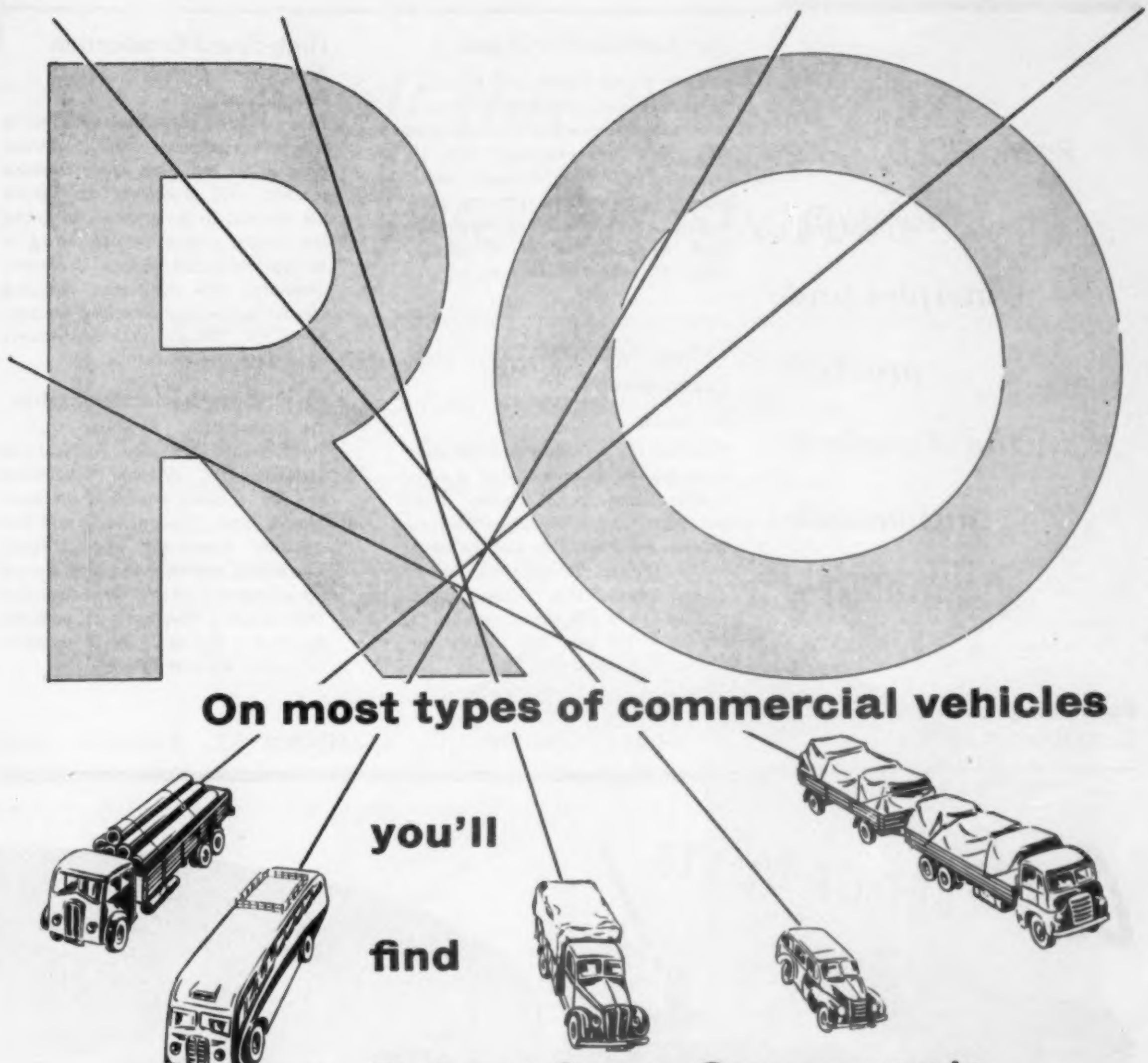
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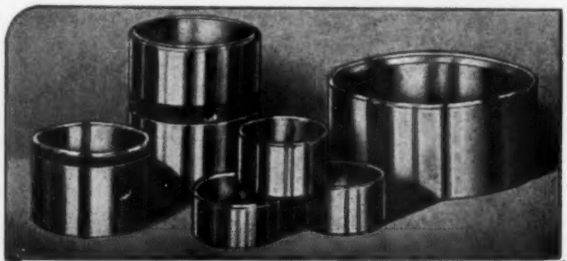

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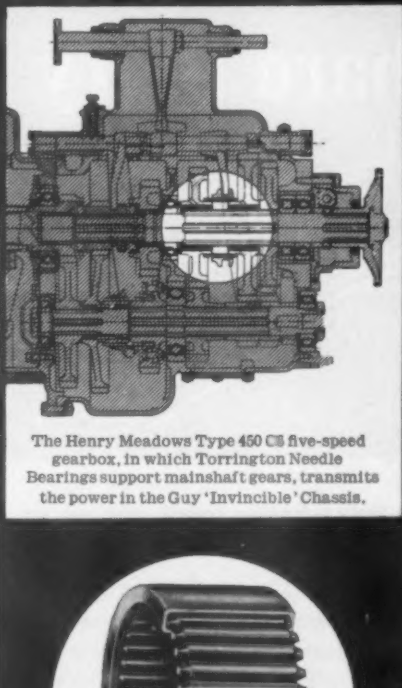

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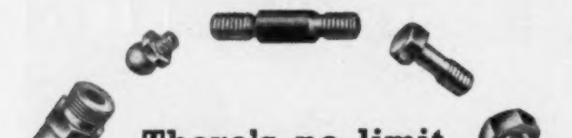

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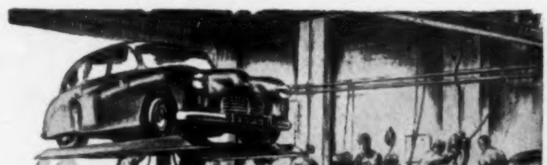

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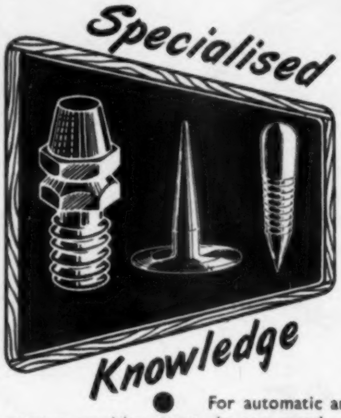

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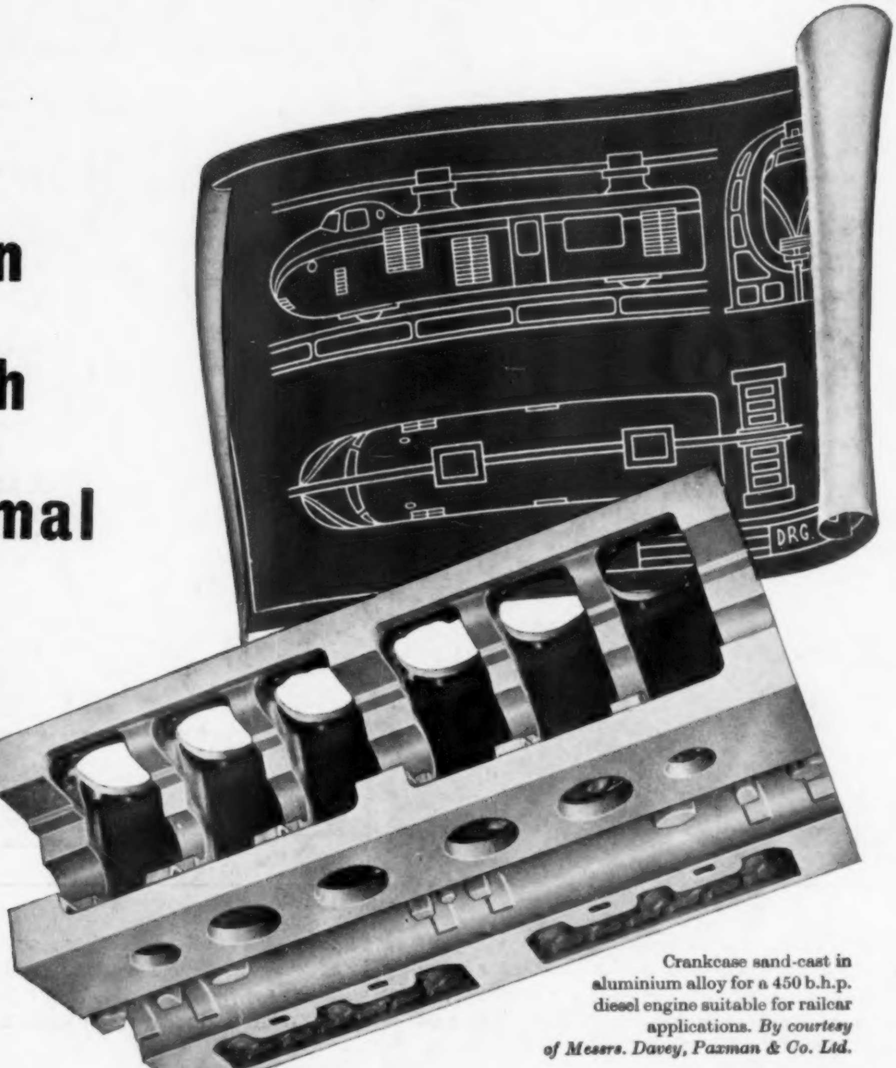

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